Facial Surgery

Defining a Preauricular Safe Zone: A Cadaveric Study of the Frontotemporal Branch of the Facial Nerve

Aesthetic Surgery Journal
2020, 1–10

DOI: 10.1093/asj/sjaa232
www.aestheticsurgeryjournal.com
OXFORD UNIVERSITY PRESS

Arda Kucukguven, MD; Mehmet Ulkir, MD; Meric Bilgic Kucukguven, DDS; Mehmet Deniz Demiryurek, MD; and Ibrahim Vargel, MD

Abstract

Background: In the preauricular region, the frontotemporal branch of the facial nerve is vulnerable to injury, which can result in facial palsy and poor cosmesis after surgical interventions.

Objectives: The purpose of this study was to describe variations in the branching patterns of the frontotemporal branch of the facial nerve and the relation between this branch and the surrounding anatomic landmarks. Based on our findings, we propose a Danger Zone and Safe Zones for preauricular interventions to avoid frontal branch injury.

Methods: Twenty cadaveric half-heads, 10 freshly frozen and 10 embalmed, were dissected. The anatomy of the auriculotemporal nerve, facial nerve, and variations of its branching pattern in the preauricular region were investigated.

Results: The mean [standard deviation] number of frontotemporal branches crossing the zygomatic arch was 2.05 [0.6]. Beginning from the X point at the apex of the intertragal notch, frontal branches ran over the zygomatic arch at a distance extending from 10 to 31 mm anterior to the tragus, which can be defined as the Danger Zone for frontal branches. Safe Zones A and B are triangular regions located behind and in front of the Danger Zone, respectively.

Conclusions: Mapping of these Safety and Danger Zones is a reliable and simple approach in preauricular interventions to avoid frontal branch injury because the facial nerve typically has multiple frontal branches. This approach provides practical information for surgeons rather than estimating the trajectory of a single frontal branch from Pitanuy's line.

Editorial Decision date: July 29, 2020; online publish-ahead-of-print August 08, 2020.

The facial nerve is an intricate structure with various branching patterns and has motor branches innervating the mimetic muscles of the face.[1] Functionally intact facial nerve branches play a critical role in social interactions, as well as in some physiologic mechanisms such as oral competence and eye closure. Injury to those branches can result in facial palsy and poor cosmesis, causing detrimental consequences, including significantly higher risk of depression and lower quality-of-life scores.[2]

In the preauricular region, the frontotemporal branch of the facial nerve is vulnerable to injury during various surgical interventions, such as facelift, temporomandibular

Dr A. Kucukguven is Chief Resident and Dr Vargel is a Professor, Hacettepe University Faculty of Medicine, Department of Plastic, Reconstructive, and Aesthetic Surgery, Ankara, Turkey. Dr Ulkir is a Resident and Dr Demiryurek is a Professor, Hacettepe University Faculty of Medicine, Department of Anatomy, Ankara, Turkey. Dr M. Kucukguven is a Research Assistant, Hacettepe University Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Ankara, Turkey.

Corresponding Author:
Dr Arda Kucukguven, Hacettepe University Faculty of Medicine, Department of Plastic, Reconstructive and Aesthetic Surgery, 06080 Sihhiye, Ankara, Turkey.
E-mail: ardakucukguven@gmail.com; Instagram: @drardakucukguven

Figure 1. Skin incision pattern (68-year-old female).

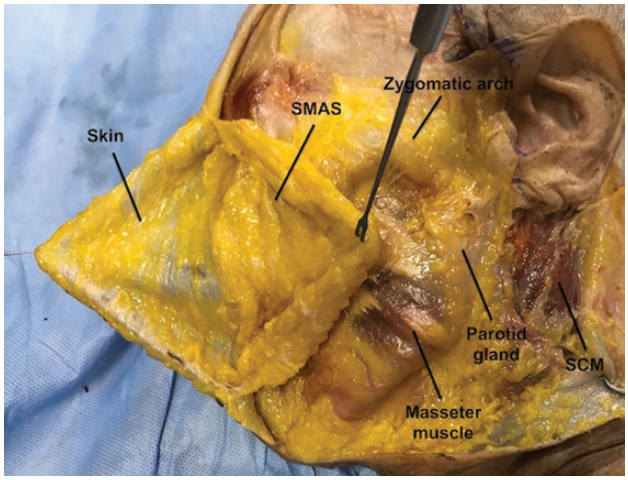

Figure 2. Elevation of the skin and SMAS flaps (68-year-old female). SMAS, superficial muscular aponeurotic system; SCM, sternocleidomastoid muscle.

joint procedures, parotid surgery, and skin lesion biopsies, as well as in infectious processes and following trauma.[3-6] Injury can occur via transection, thermal injury, or ligation, and may cause forehead paralysis and facial asymmetry. Unilateral paralysis of the frontalis muscle results in an inability to raise the eyebrow, a flattened forehead, and eyebrow ptosis. According to various reports, frontotemporal branch injury is seen in 1.5% to 32% of patients after preauricular interventions and can be permanent or temporary, usually resolving within 6 months.[7-10]

The temporofacial trunk of the facial nerve gives off temporal, frontal, and sometimes zygomatic branches.[11] The temporal and frontal branches are not clearly defined in the international nomenclature. We define the temporal branch, which has limited function in humans, as the branch innervating the auricular muscles, and the frontal branch as the branch destined to the frontal region innervating the frontalis, orbicularis oculi, and corrugator supercilii. The frontotemporal branch is the common name of the nerves of the temporal and frontal branches destined to the frontotemporal region. Any injury to the frontal branch leads to temporary or permanent functional and aesthetic sequelae, which is why preserving this branch is crucial in preauricular interventions.

The purpose of this study was to describe the variations in the branching patterns of the frontotemporal branch and its relation to the surrounding anatomic landmarks. Based on our findings, we propose a Danger Zone and Safe Zones for preauricular interventions to avoid frontal branch injury.

METHODS

The study was conducted according to the guiding principles delineated in the Declaration of Helsinki. Twenty cadaver half-heads, 10 freshly frozen and 10 embalmed, were dissected with the aid of loupe magnification between September 2019 and December 2019. The first author (A.K.) performed all dissections. To minimize distortion and nerve branch displacement, we made our measurements before releasing the posterior attachments of each nerve. First, we exposed the nerve branches under the parotidomasseteric fascia. We then left some attachments posterior to the nerves before taking measurements without releasing them completely. After that, we released the nerve branches and took photographs for demonstrative purposes.

The anatomy of the auriculotemporal nerve (ATN), facial nerve, and variations of its branching pattern in the preauricular region were investigated by making an incision beginning from the upper temporal region to the tragus and mandibular angle, making a curve towards the mentum (Figure 1). The skin and the superficial muscular aponeurotic system (SMAS) flaps were raised until reaching the lateral canthus and the oral commissure and reflected (Figure 2). The facial nerve was identified at the stylomastoid foramen and its branches were dissected in an anterograde fashion through the parotid gland under the parotidomasseteric fascia (Figure 3). The ATN was identified at the point where it turns around the mandibular condylar neck, and then continues superiorly to innervate

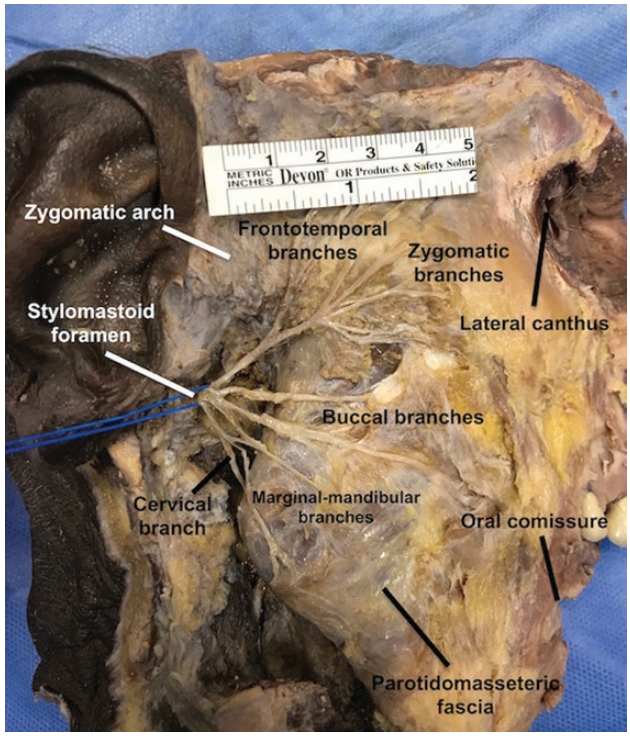

Figure 3. Facial nerve branches (64-year-old female).

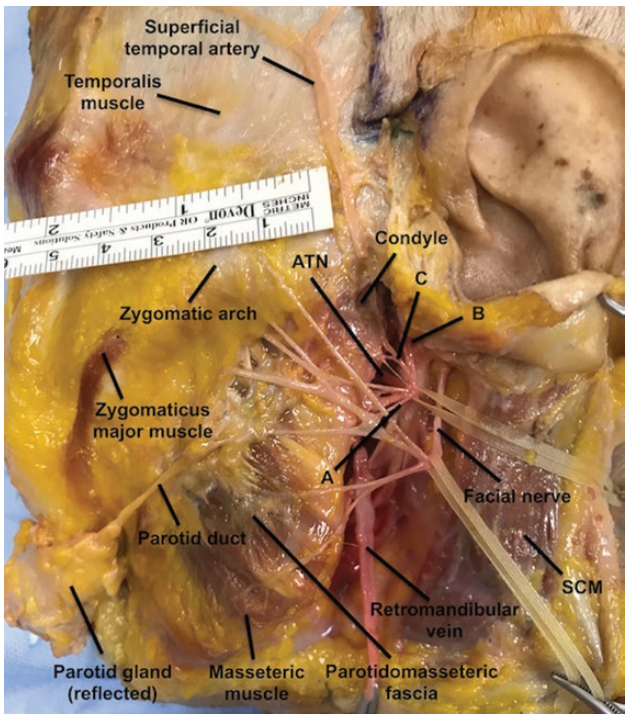

Figure 4. The auriculotemporal nerve turns around the mandibular condylar neck and continues superiorly (68-year-old female). (A) Interconnections between the ATN and facial nerve. (B, C) Terminal branches of the ATN innervating the condyle, temporal region, parts of the auricle, and preauricular skin. ATN, auriculotemporal nerve; SCM, sternocleidomastoid muscle.

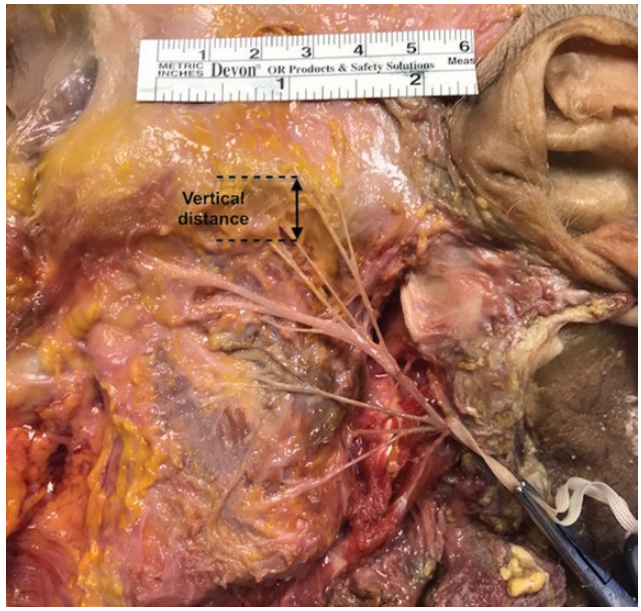

Figure 5. Arrow indicates the vertical distance between the point where the most anterior frontal branch crosses the zygomatic arch and the closest zygomatic branch (46-year-old male).

the temporal region, the condyle, parts of the auricle, and the preauricular skin (Figure 4).

The fixed landmarks were the most anterior point of the tragus (T point), the level of the zygomatic arch (midway between the superior and inferior borders), the apex of the intertragal notch (X point), and the lateral canthus (L point). The distances between the T and L points, between the T point and the ATN, and between the T point and the points where the frontal branches cross the zygomatic arch were measured. The number of temporal and frontal branches crossing the zygomatic arch was recorded. The vertical distance between the point where the most anterior frontal branch crosses the zygomatic arch and the closest zygomatic branch was measured (Figure 5). Statistical analysis was performed to analyze the T-L distance, sex, cadaver type (freshly frozen or embalmed), and average frontal branch distance to the T point to determine whether individual dimensional variations, sex, and cadaver type relate to the average frontal branch distance. Based on these measurements and findings, preauricular Safe Zones were defined for surgical intervention.

RESULTS

All subjects were white Caucasians, and their mean age was 67 years (range, 46-78 years). Of the 20 half-heads dissected (11 female, 9 male), the mean [standard deviation] T-L distance was 76.8 [3.6] mm. The predissection

Table 1. The Predissection Cadaver Data

Cadaver no.	Type	Side	Gender	Age, years	TL, mm
1	FF	Left	F	78	74
2	FF	Right	F	78	74
3	E	Left	M	57	75
4	FF	Right	F	68	71
5	FF	Left	F	68	76
6	E	Left	F	70	75
7	FF	Left	M	69	77
8	FF	Right	M	69	77
9	FF	Left	M	46	84
10	FF	Right	M	46	82
11	E	Right	F	71	73
12	E	Left	F	71	74
13	E	Right	F	69	75
14	E	Right	F	78	82
15	E	Left	F	78	80
16	E	Right	M	67	72
17	FF	Right	M	71	81
18	FF	Left	M	71	80
19	E	Right	F	64	76
20	E	Right	M	55	78
Mean (SD)				67.2 (9.5)	76.8 (3.6)

TL, tragus-lateral canthus distance; FF, fresh frozen; E, embalmed; SD, standard deviation.

anthropometric data are shown in Table 1. The mean number of frontotemporal branches crossing the zygomatic arch was 2.05 [0.6]. Temporal branches were found in 3 dissections and they innervated the auricular muscles (Figure 6). These 3 temporal branches crossed the zygomatic arch 11, 11, and 12 mm anterior to the tragus.

The ATN was found to pass somewhere between 1 and 3 mm anterior to the tragus (mean, 1.75 [0.9] mm) (Figures 4 and 7). The mean distances between the most anterior and posterior frontal branches and the T point were 23.6 [2.8] and 18.4 [3.9] mm, respectively. The mean vertical distance between the point where the most anterior frontal branch crosses the zygomatic arch and the closest zygomatic branch was 10.1 [1.8] mm.

Additionally, the SMAS layer was very thin above the zygomatic arch but the frontotemporal branches were located under the parotidomasseteric fascia over the arch. Above the arch, the frontotemporal branches coursed superficially under the superficial temporal fascia (also referred to as the temporoparietal fascia), which is the temporal extension of the SMAS. In the preauricular region, there was an areolar plane between the SMAS and parotidomasseteric fascia which facilitates the dissection of the facial nerve branches.

The temporofacial trunk passed through the X point at the apex of the intertragal notch, which was consistent in all dissections (Figure 8). Beginning from the X point, frontal branches traversed the zygomatic arch at 10 mm (B point) to 31 mm (E point) (mean, 21.0 [2.8] mm) anterior to the T point, creating an area that can be defined as the Danger Zone for the frontal branches. A 90% risk of injury is present in the triangular area between the X-C and X-D

Figure 6. (A) Auricular muscle. (B) Temporal and frontal branches (70-year-old female).

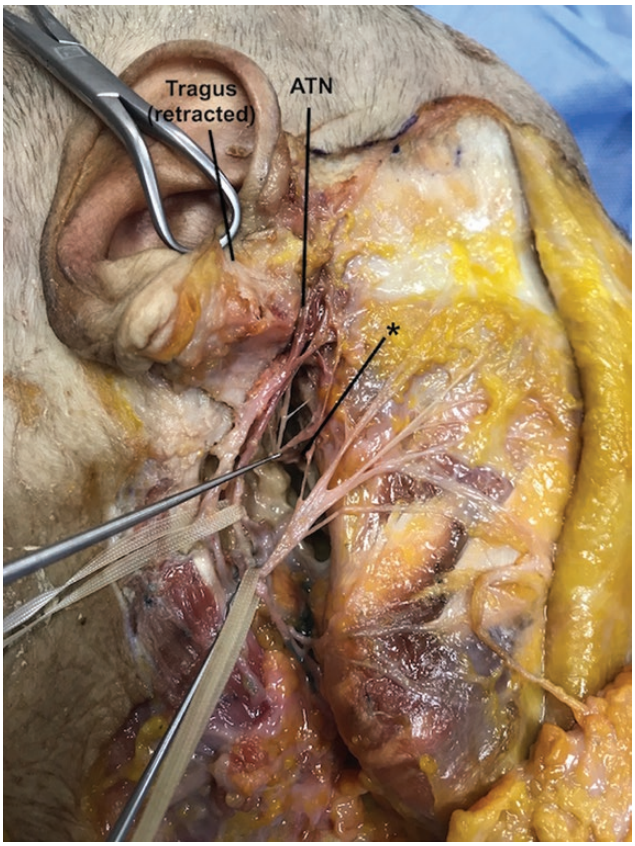

Figure 7. The auriculotemporal nerve passes anterior to the tragus (68-year-old female). ATN, auriculotemporal nerve. Asterisk indicates the ATN coming behind the condylar neck.

lines. C and D points are located 14 and 26 mm in front of the T point, respectively (Figure 9). Postdissection anatomic data are shown in Table 2. There was no statistically significant difference between the average frontal branch distance and T-L distance, sex, or cadaver type ($P > 0.05$). Safe Zone A can be defined as the triangular area between the X-A and X-B lines in which no frontal branch can be found. Safe Zone B is located between the X-E and X-F lines. F (T-F = 34.6 mm) is the closest possible point where the most superior zygomatic branch crosses the zygomatic arch (considering the minimum vertical distance of 7 mm) according to the most likely location of the most anterior frontal branch (23.6 mm anterior to the T point).

DISCUSSION

Facial nerve injury can have devastating functional and aesthetic effects on patients due to dysfunction of the frontalis and/or orbicularis oculi muscles. Following preauricular interventions, frontal branch injury, which can be permanent, or temporary with full return to function within 6 months, can be seen in up to 32% of cases.[12] There are several reasons why this branch is more susceptible to injury than other branches of the facial nerve (zygomatic, buccal, marginal-mandibular, and cervical). First, the frontotemporal branch is more superficially located, particularly over the zygomatic arch and has a lack of interconnections with other branches, leaving it at high risk of isolated injury without being reinnervated.[13,14] Due to those risks, many different surgical approaches have been

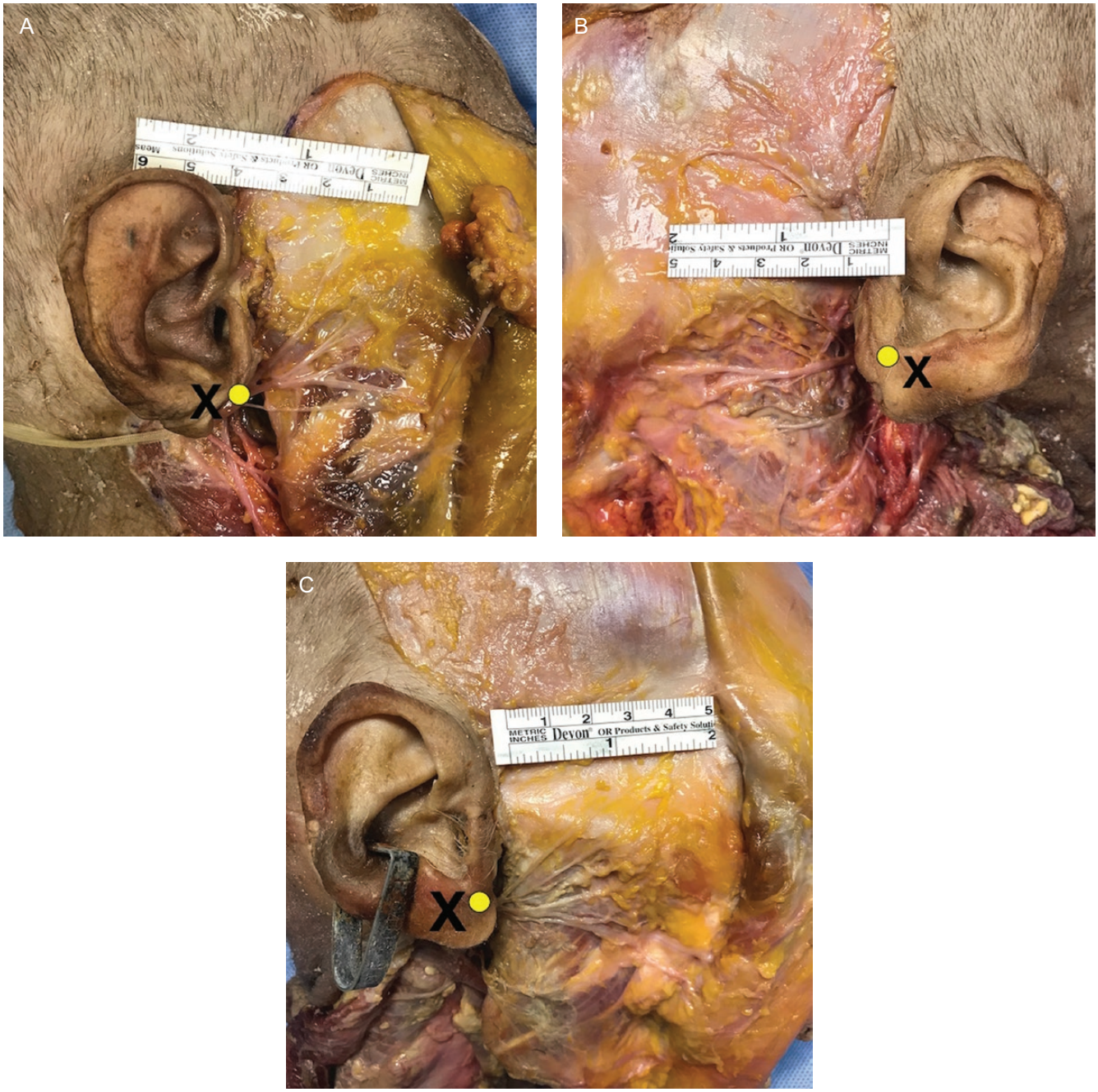

Figure 8. (A) The temporofacial trunk passes through the X point (68-year-old female). (B) The X point at the apex of the intertragal notch (46-year-old male). (C) The temporofacial trunk gives off frontotemporal and zygomatic branches after passing through the X point (46-year-old male).

described. Politi et al[14] reported that the preauricular approach is the safest and the most common approach to the preauricular region without jeopardizing the frontotemporal branch. Additionally, there are several percutaneous entry points to the temporomandibular joint for arthrocentesis and arthroscopy as described by Westesson et al[15] and Holmlund and Hellsing[16] to avoid injury to branches of the facial nerve.

Based on our findings, to avoid a potentially paralyzing injury Safe Zones A and B and the Danger Zone should be kept in mind when performing any preauricular intervention. The ATN is at increased risk of injury in preauricular interventions but rates of temporary ATN paresthesia, which only causes mild clinical complaints in affected patients, have been reported to range from 13% to 14%.[17,18] Placing preauricular incisions anterior to the tragus (<1 mm)

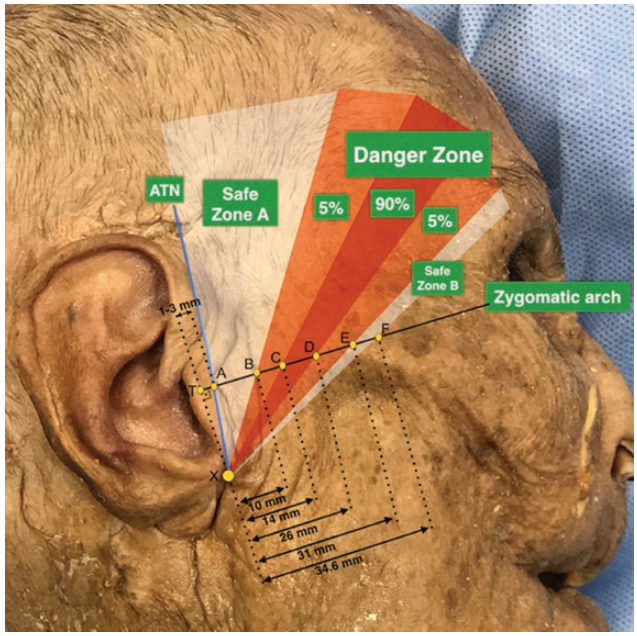

Figure 9. Danger Zone and Safe Zones A and B. The blue line represents the auriculotemporal nerve (68-year-old female). T, the most anterior point of the tragus; A, the point where the ATN crosses the zygomatic arch; B, the point where the closest frontal branch crosses the zygomatic arch; C, the beginning point of the 90% risk of injury zone over the zygomatic arch; D, the ending point of the 90% risk of injury zone over the zygomatic arch; E, the point where the most anterior frontal branch crosses the zygomatic arch; F, the closest possible point where the most superior zygomatic branch crosses the zygomatic arch (considering the minimum vertical distance of 7 mm) according to the most likely location of the most anterior frontal branch (23.6 mm anterior to the T point); X, the apex of the intertragal notch; Danger Zone, the triangular region between the X-B and X-E lines; Safe Zone A, the triangular region between the X-A and X-B lines; Safe Zone B, the triangular region between the X-E and X-F lines.

protects the ATN. Percutaneous entry points for temporomandibular joint arthrocentesis or arthroscopy should be planned according to the location of Safe Zones A and B, which helps reduce postoperative complaints of nerve injury.

Preauricular intricate anatomic planes and their relation to the frontotemporal branches, and proximity of the frontal branches to the skin, particularly over the zygomatic arch, should be kept in mind in facelift and preauricular oncologic surgery dissections. We noted that a very thin SMAS layer and the parotidomasseteric fascia protect the frontotemporal branches over the zygomatic arch, which is in accordance with the findings reported by Trussler et al.[19] We observed that the frontotemporal branches have a defined anatomic course in a uniform fascial plane. In the preauricular region, the areolar plane between the parotidomasseteric fascia and the SMAS layer makes dissection straightforward in terms of locating the frontotemporal braches. However, as the SMAS continues superiorly it becomes thinner, particularly over and above the zygomatic arch, which is why the frontal branches are prone to injury in this area. Knowledge of the 3-dimensional anatomy of the preauricular anatomy is of crucial importance in avoiding inadvertent injury to the facial nerve branches.

The temporal branch is of minor clinical importance in humans and different from the frontal branches. It innervates the auricular muscles, which when present are vestigial in humans.[20] Injury to this nerve does not lead to any functional sequelae.

Understanding of the location of the X point, which is located at the apex of the intertragal notch, is important for estimating the potential risks of frontal branch injury and accurate mapping of the frontal branch in preauricular interventions. It is the point where the temporofacial trunk passes through and subsequently gives off its frontotemporal and zygomatic branches. As there are typically 2 frontal branches crossing the zygomatic arch, we advise making preoperative plans according to the Danger Zone rather than Pitanguy's line, which states that the frontal branch is unique and courses along a line 0.5 cm below the tragus to 1.5 cm above the lateral side of the eyebrow.[21] de Bonnecaze et al[22] and Farahvash et al[23] found an average of 2.5 and 2.47 frontotemporal branches over the zygomatic arch, respectively, values that are similar to our result of 2.05. Any distal interconnections between the frontal branches may provide a compensatory mechanism should an injury to another branch occur. However, surgeons must respect each frontal branch as interconnections are not present in most cases.[22]

Although many mapping techniques based on Pitanguy's line have been proposed in the literature, there is no consensus on which surface landmarks can reliably be used. The external auditory meatus, antihelix, ear lobe, lateral canthus, and lateral orbital margin are some examples of suggested landmarks.[24-27] One study showed that those landmarks demonstrate individual variations and are not specific enough for accurate mapping of the frontal branches. That study also reported that the marking of Pitanguy's line was inconsistent between surgeons and was not an accurate representation of the distribution of the frontal branches, which is supported by our findings.[24] However, the tragus and zygomatic arch are proven surface landmarks that are consistent and used in many studies as a point of reference, which is why we used the T point (the most anterior point of the tragus) and zygomatic arch in our study.[28-30] We proposed a consistent anatomic surface landmark (X point) located at the apex of the intertragal notch, from which the temporofacial trunk passes through and gives off frontal branches. By taking the X point as a starting point

Table 2. Postdissection Anatomic Data

Cadaver no.	Frontal branch distance,[a] mm	Temporal branch distance,[b] mm	No. of FT branches[c]	T-ATN distance,[d] mm	Vertical distance between frontal and zygomatic branches[e], mm
1	24	—	1	2	7
2	22	—	1	2	9
3	10-19	—	2	1	11
4	18-23	11	3	1	9
5	23-29	—	2	3	9
6	20	12	2	2	11
7	17-23	11	3	4	8
8	22-23	—	2	2	7
9	21-26	—	2	1	10
10	20-31	—	2	1	9
11	21-23	—	2	1	9
12	22-26	—	2	2	14
13	15-23	—	2	3	13
14	14-24	—	2	2	11
15	13-23	—	2	2	10
16	14-22-25	—	3	1	11
17	21	—	1	1	12
18	21-23	—	2	1	12
19	14-18-24	—	3	2	10
20	16-21	—	2	1	10
Mean [SD]	21 [2.8]		2.05 [0.6]	1.75 [0.9]	10.1 [1.8]

[a]The distance between the anterior border of the tragus and the point where the frontal branch crosses the zygomatic arch. [b]The distance between the anterior border of the tragus and the point where the temporal branch crosses the zygomatic arch. [c]The number of the frontal and temporal (FT) branches crossing the zygomatic arch. [d]The distance between the anterior border of the tragus and the auriculotemporal nerve. [e]The vertical distance between the point where the most anterior frontal branch crosses the zygomatic arch and the closest zygomatic branch. SD, standard deviation.

and forming a Danger Zone and Safe Zones based on measurements over the zygomatic arch in front of the T point, injury to the frontal branches can easily be avoided (Figure 9). Based on those clinically applicable and consistent landmarks, this approach provides further practical information for surgeons to rely on, rather than them having to estimate the trajectory of the frontal branches.

Sanderson et al[31] found that the mean distance between the apex of the tragus and the point where the frontal branch crosses the inferior border of the zygomatic arch was 3.21 [0.05] cm. Correia et al[32] outlined the area at risk of injury as the area between 2 diverging lines originating from the earlobe, one going to the lateral end of the eyebrow and the other to the highest forehead crease. De Bonnecaze et al[22] stated that there was an increased risk of injury (>85%) in the area extending from 27.5 to 30.4 mm in front of the tragus at the level of the superior border of the zygomatic arch. In our study, we described the Danger Zone for frontal branch injury as the triangular region between 2 diverging lines starting from the X point (apex of the intertragal notch). These lines go through the points 10 and 31 mm anterior to the tragus (T point) at the level of the zygomatic arch (midway between the superior and inferior borders) (Figure 9).

The limitations of this study include that all dissections were performed on cadavers and all subjects were over 46 years old. The anatomic structures may be displaced with increasing age and become distorted in cadavers. Therefore, clinical implementation of the Safe Zones is

necessary to support the claims made here. In light of our findings, we propose that mapping of the Danger and Safe Zones is a safe and simple approach in preoperative planning of preauricular interventions.

CONCLUSIONS

The facial nerve is an intricate structure with various branching patterns. Injury to those branches results in facial palsy and poor cosmesis. In 1966, Pitanguy and Ramus[21] described the course of the frontal branch as a single line running from 0.5 cm below the tragus to 1.5 cm above the lateral eyebrow. In light of our findings, we propose that because the facial nerve typically has multiple frontal branches, mapping of triangular Safe and Danger Zones offers a reliable and simple approach to avoid frontal branch injury when performing preauricular interventions. Further studies should be conducted in live patients to further support our findings in an intraoperative setting.

Acknowledgments

The authors would like to thank Hacettepe Technopolis Technology Transfer Center for proofreading and editing the article.

Disclosures

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Funding

The authors received no financial support for the research, authorship, and publication of this article.

REFERENCES

1. Davis RA, Anson BJ, Budinger JM, Kurth LR. Surgical anatomy of the facial nerve and parotid gland based upon a study of 350 cervicofacial halves. *Surg Gynecol Obstet.* 1956;102(4):385-412.
2. Nellis JC, Ishii M, Byrne PJ, Boahene KDO, Dey JK, Ishii LE. Association among facial paralysis, depression, and quality of life in facial plastic surgery patients. *JAMA Facial Plast Surg.* 2017;19(3):190-196.
3. Moin A, Shetty AD, Archana TS, Kale SG. Facial nerve injury in temporomandibular joint approaches. *Ann Maxillofac Surg.* 2018;8(1):51-55.
4. Visconti G, Salgarello M. Anatomical considerations to prevent facial nerve injury: insights on frontal branch and cervicofacial trunk nerve anatomy in SMAS face lifts. *Plast Reconstr Surg.* 2016;137(4):751e-752e.
5. Carta F, Chuchueva N, Gerosa C, Sionis S, Caria RA, Puxeddu R. Parotid tumours: clinical and oncologic outcomes after microscope-assisted parotidectomy with intraoperative nerve monitoring. *Acta Otorhinolaryngol Ital.* 2017;37(5):375-386.
6. Owusu JA, Parker NP, Rimell FL. Postoperative facial nerve function in pediatric parotidectomy: a 12-year review. *Otolaryngol Head Neck Surg.* 2013;148(2):249-252.
7. Chaffoo RA. Complications in facelift surgery: avoidance and management. *Facial Plast Surg Clin North Am.* 2013;21(4):551-558.
8. Matarasso A, Elkwood A, Rankin M, Elkowitz M. National plastic surgery survey: face lift techniques and complications. *Plast Reconstr Surg.* 2000;106(5):1185-95; discussion 1196.
9. Weinberg S, Kryshtalskyj B. Facial-nerve function following temporomandibular-joint surgery using the preauricular approach. *J Oral Maxil Surg*. 1992;50(10):1048-1051.
10. Nellestam P, Eriksson L. Preauricular approach to the temporomandibular joint: a postoperative follow-up on nerve function, hemorrhage and esthetics. *Swed Dent J.* 1997;21(1-2):19-24.
11. Gataa IS, Faris BJ. Patterns and surgical significance of facial nerve branching within the parotid gland in 43 cases. *Oral Maxillofac Surg.* 2016;20(2):161-165.
12. Liu F, Giannakopoulos H, Quinn PD, Granquist EJ. Retrospective study of facial nerve function following temporomandibular joint arthroplasty using the endaural approach. *Craniomaxillofac Trauma Reconstr.* 2015;8(2):88-93.
13. Agarwal CA, Mendenhall SD 3rd, Foreman KB, Owsley JQ. The course of the frontal branch of the facial nerve in relation to fascial planes: an anatomic study. *Plast Reconstr Surg.* 2010;125(2):532-537.
14. Politi M, Toro C, Cian R, Costa F, Robiony M. The deep subfascial approach to the temporomandibular joint. *J Oral Maxillofac Surg.* 2004;62(9):1097-1102.
15. Westesson PL, Eriksson L, Liedberg J. The risk of damage to facial nerve, superficial temporal vessels, disk, and articular surfaces during arthroscopic examination of the temporomandibular joint. *Oral Surg Oral Med Oral Pathol.* 1986;62(2):124-127.
16. Holmlund A, Hellsing G. Arthroscopy of the temporomandibular joint. An autopsy study. *Int J Oral Surg.* 1985;14(2):169-175.
17. Dolwick MF, Kretzschmar DP. Morbidity associated with the preauricular and perimeatal approaches to the temporomandibular joint. *J Oral Maxillofac Surg.* 1982;40(11):699-700.
18. Smith JA, Sandler NA, Ozaki WH, Braun TW. Subjective and objective assessment of the temporalis myofascial flap in previously operated temporomandibular joints. *J Oral Maxillofac Surg.* 1999;57(9):1058-65; discussion 1065.
19. Trussler AP, Stephan P, Hatef D, Schaverien M, Meade R, Barton FE. The frontal branch of the facial nerve across the zygomatic arch: anatomical relevance of the high-SMAS technique. *Plast Reconstr Surg.* 2010;125(4):1221-1229.
20. Liugan M, Zhang M, Cakmak YO. Neuroprosthetics for auricular muscles: neural networks and clinical aspects. *Front Neurol.* 2017;8:752.

21. Pitanguy I, Ramos AS. The frontal branch of the facial nerve: the importance of its variations in face lifting. *Plast Reconstr Surg.* 1966;38(4):352-356.
22. de Bonnecaze G, Chaput B, Filleron T, Al Hawat A, Vergez S, Chaynes P. The frontal branch of the facial nerve: can we define a safety zone? *Surg Radiol Anat.* 2015;37(5):499-506.
23. Farahvash MR, Yaghoobi A, Farahvash B, Farahvash Y, Hadadi Abiyaneh S. The extratemporal facial nerve and its branches: analysis of 42 hemifacial dissections in fresh Persian (Iranian) cadavers. *Aesthet Surg J.* 2013;33(2):201-208.
24. Davies JC, Fattah A, Ravichandiran M, Agur AM. Clinically relevant landmarks of the frontotemporal branch of the facial nerve: a three-dimensional study. *Clin Anat.* 2012;25(7):858-865.
25. Miloro M, Redlinger S, Pennington DM, Kolodge T. In situ location of the temporal branch of the facial nerve. *J Oral Maxillofac Surg.* 2007;65(12):2466-2469.
26. Ammirati M, Spallone A, Ma J, Cheatham M, Becker D. An anatomicosurgical study of the temporal branch of the facial nerve. *Neurosurgery.* 1993;33(6):1038-43; discussion 1044.
27. Gosain AK, Sewall SR, Yousif NJ. The temporal branch of the facial nerve: how reliably can we predict its path? *Plast Reconstr Surg.* 1997;99(5):1224-33; discussion 1234.
28. Coward TJ, Watson RM, Scott BJ. Laser scanning for the identification of repeatable landmarks of the ears and face. *Br J Plast Surg.* 1997;50(5):308-314.
29. Sharma VS, Stephens RE, Wright BW, Surek CC. What is the lobular branch of the great auricular nerve? Anatomical description and significance in rhytidectomy. *Plast Reconstr Surg.* 2017;139(2):371e-378e.
30. Alghoul M, Bitik O, McBride J, Zins JE. Relationship of the zygomatic facial nerve to the retaining ligaments of the face: the sub-SMAS danger zone. *Plast Reconstr Surg.* 2013;131(2):245e-252e.
31. Green Sanderson K, Conti A, Colussi M, Connolly C. A simple clinical application for locating the frontotemporal branch of the facial nerve using the zygomatic arch and the tragus. *Aesthet Surg J.* 2019;40(5):NP223-NP227.
32. Correia Pde C, Zani R. Surgical anatomy of the facial nerve, as related to ancillary operations in rhytidoplasty. *Plast Reconstr Surg.* 1973;52(5):549-552.