The Anatomy of the Superficial Temporal Artery in Adult Koreans Using 3-Dimensional Computed Tomographic Angiogram: Clinical Research

Byung Soo Kim, Young Jin Jung, Chul Hoon Chang, Byung Yon Choi
Department of Neurosurgery, Yeungnam University, College of Medicine, Daegu, Korea

Objective: The increased use of bypass surgery in the treatment of ischemic cerebrovascular diseases requires a better understanding of the superficial temporal artery (STA) anatomy. This study is to describe the gross anatomy of STA in adult Korean population with respect to cranial surgery and to provide basic anatomic data for bypass surgery.

Methods: The study evaluated retrospectively 35 patients who visited the neurosurgery department at a single institution. For each patient, both the left and right STA (70 vessels) were evaluated by a 3-dimensional computed tomographic angiogram for diameter and anatomic relationships to external landmarks.

Results: Of 70 STAs, 69 had a bifurcation. Among these, 57 (82.6%) were above the superior margin of the zygomatic arch. The STA bifurcation was 53.2 ± 5.9 mm posterior to the keyhole, 9.5 ± 5.3 mm anterior to the posterior margin of condylar process of the mandible, and 21.7 ± 15.8 mm superior to the superior margin of the zygomatic arch. The inner diameter of the STA was 1.8 ± 0.5 mm at the superior margin of the zygomatic arch, and 1.4 ± 0.4 mm and 1.4 ± 0.5 mm for frontal and parietal branches, respectively. The 75.7% of frontal and 66.7% of parietal branches were suitable for microvascular anastomosis.

Conclusion: This present study demonstrated the STA in Korean adults, which may benefit the clinician in dealing with the surgical procedures related to this STA.

Keywords: Carotid artery, External, Temporal arteries

INTRODUCTION

The superficial temporal artery (STA) is one of the terminal branches of the external carotid artery (ECA). It supplies the face and scalp together with other branches of the ECA. The STA is one of the primary bypass conduits used to distally perfuse the brain in ischemic cerebrovascular disease or an intracranial complex lesion, and for this reason, the importance of understanding the anatomy of the STA is growing. Ethnic anatomic differences may exist for the STA, but the gross anatomy of the STA in Korean adult population has not been reported in detail.

The outer diameter of STA has been generally investigated by cadaver studies, and only 1 study reports the inner diameter by the use of conventional angiogram. The objective of this study was to evaluate the distance of STA bifurcation from the superior...
Fig. 1. Location of the superficial temporal artery (STA) bifurcation. The relationship between STA and pericranial structures. (a: distance from the posterior margin of the mandibular condyle, b: distance from the superior margin of the zygomatic arch, c: distance from the keyhole).

The mean age of the 35 subjects was 58.9 years (± 10.8) with a range from 35 to 82. Among the 70 studied, 69 STAs had at least 1 bifurcation with 1 STA having only the frontal branch. Fifty-seven (82.6%) STAs had bifurcations above the superior margin of the zygomatic arch; 7 (10.1%) over the zygomatic arch; and 5 (7.2%) had bifurcations below the inferior margin of the zygomatic arch (Table 1).

The location of STA bifurcation was 9.5 (± 5.3) mm anterior to the posterior margin of the mandibular condyle, 21.7 (± 15.8) mm superior to the superior margin of the zygomatic arch, and 53.2 (± 5.9) mm posterior to the keyhole (Table 2, Fig. 1).

The mean inner diameter of STAs was 1.8 ± 0.5 mm at the superior margin of the zygomatic arch, 1.8 ± 0.6 mm at 1 cm above the superior margin of the zygomatic arch, and 1.9 ± 0.8 mm at 1 cm below the bifurcation. The diameters of the frontal and parietal branches were 1.4 ± 0.4 mm and 1.4 ± 0.5 mm at 1 cm
Fig. 2. Anatomic dimensions of superficial temporal artery (STA). Using the data from 3-dimensional computed tomography angiogram, the length and diameter of each STA was measured without histographic adjustment. (A) If 2 points (blue and red) were assigned, (B) the program automatically calculated the length between these 2. (C, D) In addition, the average diameter was calculated automatically for these points.

Distal from bifurcation, respectively. The diameter of the same frontal and parietal branches were 1.2 ± 0.5 mm and 1.1 ± 0.6 mm at 7 cm distal from the superior margin of the zygomatic arch, respectively (Table 3).

Suitable branches of STA for bypass surgery are defined as having a diameter larger than 1 mm with a
The superficial temporal artery arises from the external carotid artery. It runs along the posterior margin of the condylar process of mandible, and crosses the posterior root of the zygomatic process of the temporal bone.\textsuperscript{1,9} Above the zygomatic arch, it divides into 2 large terminal branches. The anterior branch is called the frontal branch and courses anterosuperiorly. The posterior branch is called the parietal branch and is directed posterosuperiorly.\textsuperscript{6} During cranial surgery, understanding its anatomic relationship with specific landmarks of the pericranial region is helpful in identifying the location of both the artery itself and the point of bifurcation.

The STA usually bifurcates at a point above the superior margin of the zygomatic arch, and the results of our study are similar to others from the literature regarding STA anatomy (Table 4). Mwachaka et al.\textsuperscript{4} used the zygomatic arch, lateral canthus, and tragus as a landmark. Chen et al.\textsuperscript{2} used the zygomatic process and external auditory canal. In this study, posterior margin of the mandible condyle, superior margin of the zygomatic arch, and keyhole were used as 3 landmarks to detect the location of the STA bifurcation, because these are readily identifiable in the operative field. In this study, the standard deviations for the location measurements were relatively high, and reveal that the STA anatomy has many variations. However, this approximation is still adequate in understanding STA anatomy and in identifying the location of bifurcation, helpful in preserving the STA during a cranial operation.

The diameter of the STA at superior margin of the zygomatic arch was 1.8 ± 0.5 mm. The diameters of STA at the point of bifurcation is variable, and this diameter was measured at a point 1 cm below the bifurcation, where it was slightly larger (1.9 ± 0.8 mm) than at the superior margin of zygomatic arch. As the STA passes through the connective tissue around the zygomatic arch, it takes on a hairpin shape to allow flexibility for the movements of mastication. This appears to be why the distal artery has a larger diameter than that of the proximal portion. Furthermore, 12 STAs in this study were found to bifurcate over or below the zygomatic arch. In these cases, the proximal STA bifurcation has a larger diameter than it does at

---

**Table 1. The location of STA bifurcation**

| Location                                      | Number (%)|
|----------------------------------------------|-----------|
| Above the superior margin of zygomatic arch  | 57 (82.6) |
| Over the zygomatic arch                      | 7 (10.1)  |
| Below the inferior margin of zygomatic arch  | 5 (7.2)   |

Sixty nine STA had bifurcation among 70, 1 had only frontal branch. STA= superficial temporal artery.

---

**Table 2. The location of STA bifurcation relative to pericranial structures**

| Pericranial structure     | Distance to bifurcation (mean ± SD mm) |
|---------------------------|----------------------------------------|
| Posterior margin of mandibular condyle | 9.5 ± 5.3                               |
| Zygomatic arch             | 21.7 ± 15.8                             |
| Keyhole                    | 53.2 ± 5.9                              |

STA= superficial temporal artery; SD= standard deviation.
Table 3. Inner diameter of STA

| Location                                      | Inner diameter of STA (mean ± SD mm) |
|-----------------------------------------------|--------------------------------------|
| Superior margin of ZA                        | 1.8 ± 0.5                            |
| 1 cm above superior margin of ZA              | 1.8 ± 0.6                            |
| 1 cm below the STA bifurcation                | 1.9 ± 0.8                            |
| Frontal branch†                               | 1.4 ± 0.4                            |
| Parietal branch†                              | 1.4 ± 0.5                            |
| 7 cm from ZA to frontal branch                | 1.2 ± 0.5                            |
| 7 cm from ZA to parietal branch               | 1.1 ± 0.6                            |

†Frontal branch was measured at 1 cm distal from bifurcation to frontal branch, †Parietal branch was measured at 1 cm distal from bifurcation to parietal branch. STA= superficial temporal artery; SD= standard deviation; ZA= zygomatic arch.

the distal zygomatic arch. In fact, among the 57 STAs with bifurcations above the zygomatic arch, the diameter at 1 cm below the bifurcation was 1.7 ± 0.5 mm. Some studies have found that the diameter of the parietal branch is larger than that of the frontal branch. However, we did not find any significant difference in the diameter of frontal and parietal branches.

In this study, the STA diameter at the zygomatic arch was 1.8 ± 0.5 mm, but others have reported the STA diameter at the same location to be between 2.0 mm to 2.7 mm (Table 5). This difference can be explained by the differences in study design. In previous reports, these measurements were obtained in cadaver studies with the STA expanded by preservative fluids, whereas contrasted CT angiogram in live human subjects was used in our study. In our case, the STA measurement may have been made during either systole or diastole; and therefore, the measurements made on a pulsating artery could be smaller than the artificially expanded artery from cadaver studies. Furthermore, the study measurements on CT images were for inner diameter of the artery, whereas the measurements made in cadaver studies was that of the outer diameter and included the thickness of the vessel wall into the overall diameter. In a study by Stock et al.,7) the average diameter of STA at the zygomatic arch was 2.0 ± 0.3 mm in cadavers and was 1.9 ± 0.7 mm in a radiologic study in live human subjects. In that study, the radiologic diameters were smaller by 5% at the zygomatic arch, 18% at the frontal branch, and 28% at the parietal branch, when compared with those measurements from cadavers. Chen et al.2) reported a cadaveric study on STA anatomy in Chinese population. In that study, the STA diameter was 2.1 ± 0.5 mm at the zygomatic arch, 1.6 ± 0.2 mm at the frontal branch, and 1.7 ± 0.2 mm at the parietal branch (Table 5). The STA measurements in this study of Korean population were smaller than the Chinese equivalent by 14% at the zygomatic arch, 12% at the frontal branch, and 18% at the parietal branch, re-

Table 4. Bifurcation point of the STA in literature (%)

| Authors                      | Above the ZA | Over the ZA | Below the ZA |
|------------------------------|--------------|-------------|--------------|
| Chen et al.2) (cadaveric)    | 86.5         | 3.8         | 9.6          |
| Stock et al.7) (radiological)| 60.0         | 32.0        | 8.0          |
| Marano et al.3) (cadaveric)  | 9.7          | 4.3         | N/D          |
| Pinar et al.5) (cadaveric)   | 74.1         | 22.2        | N/D          |
| Mwachaka et al.6) (cadaveric)| 80           | 13.3        | 6.7          |
| Tayfur et al.8) (cadaveric)  | 62           | N/D         | 38           |
| Current study (radiological) | 84.1         | 8.7         | 7.2          |

STA= superficial temporal artery; ZA= zygomatic arch; N/D= no data.
spectively, at the zygomatic arch, frontal and parietal branches. When taking into consideration the difference between inner and outer diameter measurements, the anatomic dimensions of STA appears similar across these 2 populations. Furthermore, STA diameters in the East Asian population, which includes Chinese or Korean ethnic groups, appear to be less than that of western populations.

Suitable branches of STA for bypass surgery are defined as having a diameter larger than 1 mm with a length greater than 70 mm from the superior margin of the zygomatic arch. By these criteria, 75.7% of the frontal branches and 66.7% of the parietal branches were suitable for bypass surgery in this population. In comparison, Marano et al. and Pinar et al. reported higher rates of suitability in their populations (Table 6). This discrepancy suggests that a smaller proportion of Korean patients requiring bypass operation may have a suitable STA compared to patients elsewhere. Further, we measured the inner diameter of the STA branch, so the thickness of the vessel walls presumably accounts for some parts of the difference.

The rate of suitable branch of the frontal STA was bigger than the parietal branch (Table 6). However, there was no significant difference between them.

To save the STA during cranial surgery, we drew the imaginary line of the STA considering the relationship with pericranial structures and CTA, then dissected carefully from the distal part. We undermined over it pulling the skin by forcep, if it met STA trunk or branch. Saving STA trunk is critically important, and the skin incision would be posterior to STA trunk rather than anterior at tragus level.

The limitation of this study is selection of patients. Among the patients evaluated in this study, there were 13 with hemorrhagic diseases, 8 ischemic diseases, 11 with unruptured aneurysms, and 3 with meningiomas. Most patients had vascular disease, and more studies are needed whether patients with vascular disease have more atherosclerosis.

### Conclusion

The location of STA bifurcation was 9.5 ± 5.3 mm anterior to the posterior margin of the mandible condyle, 21.7 ± 15.8 mm superior to the superior margin of the

### Table 5. Diameters of STA (mm)

| Authors                         | Zygomatic arch | Frontal branch | Parietal branch |
|---------------------------------|----------------|----------------|-----------------|
| Chen et al. [2] (cadaveric)     | 2.1 ± 0.5      | 1.6 ± 0.2      | 1.7 ± 0.2       |
| Stock et al. [1] (radiological) | 1.9 ± 0.7      | 1.4 ± 0.4      | 1.3 ± 0.5       |
| Stock et al. [1] (cadaveric)    | 2.0 ± 0.3      | 1.7 ± 0.5      | 1.8 ± 0.3       |
| Marano et al. [3] (cadaveric)   | 2.2            | N/D            | N/D             |
| Pinar et al. [5] (cadaveric)    | 2.7 ± 0.5      | 2.1 ± 0.5      | 1.8 ± 0.5       |
| Tayfur et al. [8] (cadaveric)   | 2.5            | 1.8            | 1.8             |
| Current study (radiological)    | 1.8 ± 0.5      | 1.4 ± 0.4      | 1.4 ± 0.5       |

Stock et al. [2] (radiological) and current study measured inner diameters of the superficial temporal artery of living people, but other’s measured outer diameters of cadavers.

### Table 6. Percentage of STA suitable for use in bypass [%]

| Authors       | Frontal branch | Parietal branch |
|---------------|----------------|-----------------|
| Marano [3]    | 90.0           | 71.4            |
| Pinar [5]     | 89.0           | 78.0            |
| Current study | 75.7           | 66.7            |

In our study, one case did not have a parietal branch. Thus, the proportion of frontal branches was 53 out of 70, whereas that of parietal branches was 46/69. STA = superficial temporal artery.
zygomatic arch, and 53.2 ± 5.9 mm posterior to the keyhole. The diameter of STA measured in the adult Korean population is less than that published for Western populations. However, our result is similar to the findings reported in the Chinese population. Considering the high standard deviations of STA anatomy, 3D CTA study might be helpful in the preoperative setting. Even if the image modality is not available however, a better understanding of the STA anatomy in its relationship to the landmark structures would help to preserve this important artery during a cranial operation.

REFERENCES

1. Abul-Hassan HS, von Drasek Ascher G, Acland RD. Surgical anatomy and blood supply of the fascial layers of the temporal region. Plast Reconstr Surg. 1986 Jan;77(1):17-28.

2. Chen TH, Chen CH, Shyu JF, Wu CW, Lui WY, Liu JC. Distribution of the superficial temporal artery in the Chinese adult. Plast Reconstr Surg. 1999 Oct;104(5):1276-9.

3. Marano SR, Fischer DW, Gaines C, Sonntag VK. Anatomical study of the superficial temporal artery. Neurosurgery. 1985 Jun;16(6):786-90.

4. Mwachaka P, Sinkeet S, Ogeng'o J. Superficial temporal artery among Kenyans: Pattern of branching and its relation to pericranial structures. Folia Morphol (Warsz). 2010 Feb;69(1):51-3.

5. Pinar YA, Govsa F. Anatomy of the superficial temporal artery and its branches: Its importance for surgery. Surg Radiol Anat. 2006 Jun;28(3):248-53.

6. Sinna R, Hajji H, Qasemyar Q, Perignon D, Benhaim T, Havet E. Anatomical background of the perforator flap based on the deep branch of the superficial circumflex iliac artery (SCIP Flap): A cadaveric study. Eplasty. 2010 Jan;10:e11.

7. Stock AL, Collins HP, Davidson TM. Anatomy of the superficial temporal artery. Head Neck Surg. 1980 Jul-Aug;2(6):466-9.

8. Tayfur V, Edizer M, Magden O. Anatomic bases of superficial temporal artery and temporal branch of facial nerve. J Craniofac Surg. 2010 Nov;21(6):1945-7.

9. Yonenaga K, Tohrai I, Mitsudo K, Mori Y, Saijo H, Iwai T, et al. Anatomical study of the external carotid artery and its branches for administration of super-selective intra-arterial chemotherapy via the superficial temporal artery. Int J Clin Oncol. 2011 Dec;16(6):654-9.