RESULTS

The middle temporal vein was located beneath the superficial layer of the deep temporal fascia and was distributed in the temporal fat pad (Fig. 1). As the middle temporal vein passed back to the proximal side, the middle temporal vein pierced and ran several millimeters over the surface of the superficial layer of the deep temporal fascia and temporal bone (distance E in Fig. 3). Finally, the middle temporal vein joined the main trunk of the superficial temporal vein. In addition, the junction of the middle temporal vein and the superficial temporal vein was located remotely from the parotid gland; therefore, surgeons do not have to worry about damaging the parotid gland because this gland is not usually exposed during the dissection.

The middle temporal vein was identified in all specimens, and the overall caliber of male and female specimens is described in Table 1. Corresponding data with regard to the superficial temporal vein in the same specimens is also listed in Table 1 for comparison. There was no significant difference when comparing the overall caliber of the middle temporal vein and that of the superficial temporal vein ($p = 0.574$), and there was no significant difference in the caliber of the middle temporal vein and superficial temporal vein when comparing male specimens ($p = 0.408$) with female specimens ($p = 0.205$). Although the caliber of the middle temporal vein tended to be larger in male specimens than in female specimens, this difference did not reach the level of statistical significance ($p = 0.178$).

In the superficial fat pad, the middle temporal vein was distributed according to one of four representative running patterns (Fig. 4): type 1, which had only one major trunk; type 2, which had two rather large major trunks that ran in parallel and that joined one major trunk; type 3, which had one major trunk with one rather small descending branch that eventually joined together; and type 4, which had one major trunk with two rather small descending branches that joined together. In addition, Figure 5 shows these running patterns of the middle temporal vein in a clinical situation. Among these four types of middle temporal vein distributions, we defined the "plexus type" as a distribution with many tiny reticular vessels around a major trunk (Fig. 6). Distribution types and differences between male and female specimens are summarized in Tables 2 and 3. The most common distribution pattern was type 1 in male specimens and type 3 and type 1 in female specimens. Female specimens had more of the plexus type, which accounted for a little more than half of the specimens (53 percent), but this difference between male and female specimens did not reach the level of statistical significance ($p = 0.194$).

The measured distance between the middle temporal vein and each landmark is shown in Figures 2 and 3 and in Table 4. There was no specific or significant difference related to these landmarks when comparing male and female specimens.

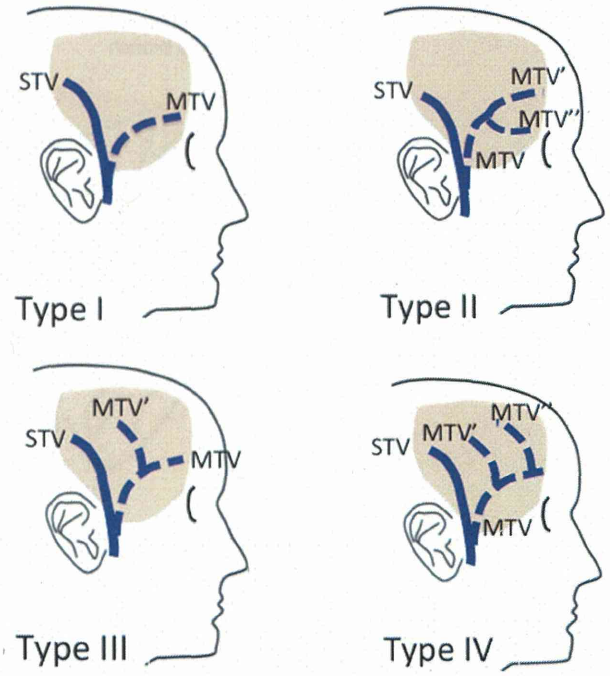

Fig. 4. Distribution patterns of the middle temporal vein. (*Above, left*) Type 1, which has only one major trunk of the middle temporal vein. (*Above, right*) Type 2, which has two major trunks of the middle temporal vein. (*Below, left*) Type 3, which has one major trunk of the middle temporal vein with one small branch. (*Below, right*) Type 4, which has one major trunk of the middle temporal vein with two small branches. *MTV*, middle temporal vein; *STV*, superficial temporal vein.

Table 1. Caliber of Middle and Superficial Temporal Veins

	Range (mm)	Average ± SD (mm)
MTV		
Overall	0.6–4.0	1.88 ± 0.86
Male	0.9–4.0	1.99 ± 0.86
Female	0.6–3.9	1.78 ± 0.87
STV		
Overall	0.9–3.4	1.79 ± 0.54
Male	1.4–3.4	2.05 ± 0.53
Female	0.9–2.7	1.62 ± 0.48

MTV, middle temporal vein; STV, superficial temporal vein.

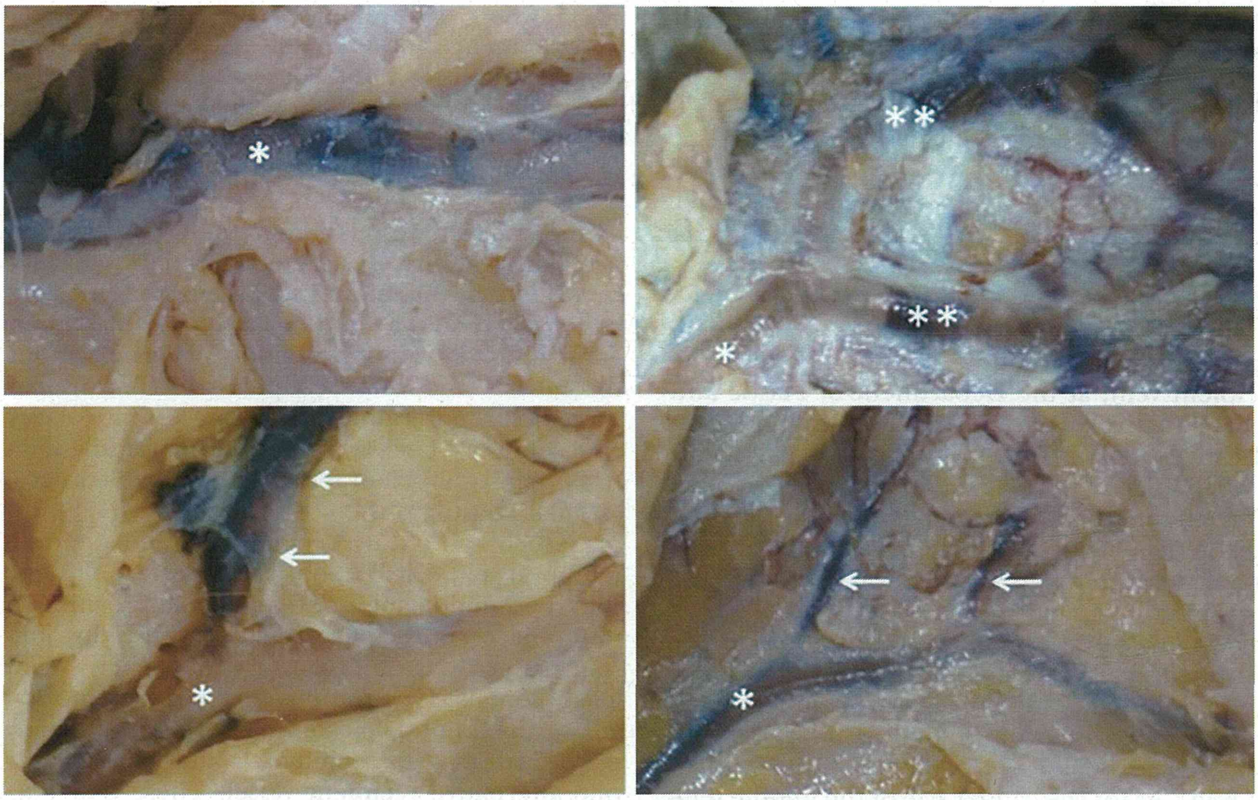

Fig. 5. Distribution patterns of the middle temporal vein in clinical cases (*above, left*, type I; *above, right*, type II; *below, left*, type III; *below, right*, type IV). The *asterisk* indicates the main trunk of the middle temporal vein. (*Above, right*) The *double asterisks* indicate two major trunk of the middle temporal vein. (*Below*) The *arrows* indicate a small branch of the middle temporal vein.

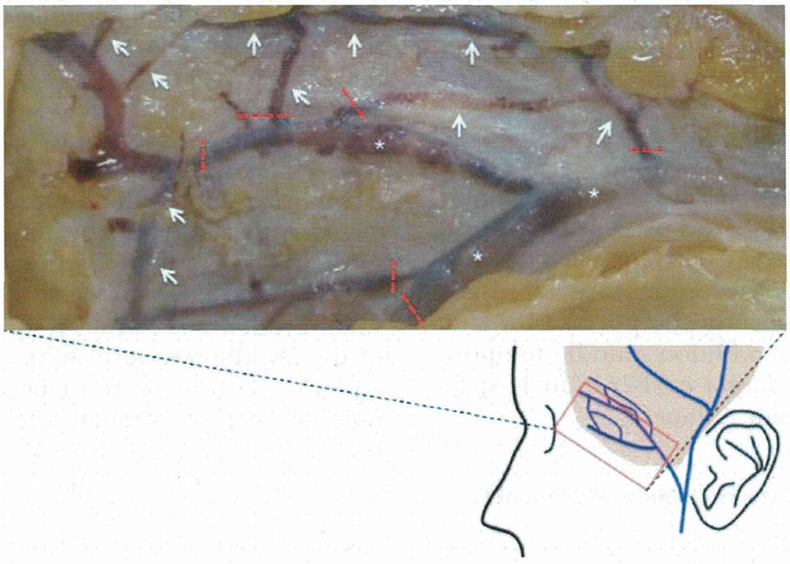

Fig. 6. The *asterisks* show the main major trunk of the middle temporal vein, and the *arrows* around the middle temporal vein indicate mesh-like small branches, which we defined as plexus-type. In addition, the *red dotted lines* indicate the small branches, which should be carefully ligated or coagulated before the middle temporal vein is harvested.

Table 2. Frequency of Each Distribution Pattern, and Frequency of Plexus Pattern

Type	Plexus-Type	Non–Plexus-Type	No. (%)
I	19	9	28 (47)
II	6	2	8 (13)
III	7	11	18 (30)
IV	1	5	6 (10)
Total, no. (%)	33 (55)	27 (45)	

Clinical Case Series

To date, we have had 17 cases of free flap transfer using the middle temporal vein as the recipient vein, at the Department of Plastic and Reconstructive Surgery, Tokyo Medical and Dental University Hospital, from May of 2007 to May of 2013. There were 10 male and seven female cases; the mean age of the patients was 45 years and the age range was 9 to 62 years. An anterolateral thigh free flap was used in 15 cases and a deep inferior epigastric perforator free flap was used in two cases. The middle temporal vein was identified in all patients, and typical dissection of the middle temporal vein is shown in Figure 7. The average caliber of the middle temporal vein in these cases was 1.81 ± 0.56 mm (range, 0.7 to 2.5 mm). As for the caliber size of the middle temporal vein, it seemed that there was a rather good correlation between clinical case series and our cadaver study. In seven of 17 cases of flap reconstruction, the middle temporal vein alone was used, and in 10 of 17 cases, both the middle temporal vein and the superficial temporal vein were used. No flap loss or venous thrombosis occurred postoperatively.

DISCUSSION

According to the consecutive cadaver study, the middle temporal vein was present in all specimens and was of adequate size for microvascular anastomosis. These observations are consistent with those of previous clinical reports of the middle temporal vein.[8] In addition, middle temporal veins tended to be of larger caliber in male specimens than in female specimens.

Table 3. Distribution Pattern in Male and Female Specimens

Type	Male Specimens ($n = 30$)	Female Specimens ($n = 30$)
I	16	12
II	4	4
III	5	13
IV	5	1
Plexus-type	11 (37%)	16 (53%)

However, the average size of the middle temporal vein in cadavers, 1.88 ± 0.86 mm, might seem rather small for successful microvascular anastomosis. Hong and Koshima[10] reported that vessel size of less than 1 mm may increase the risk of flap failure, and Upton and Guo[11] reported in their 433 free tissue transfers in children that, in toe transfer, vessels larger than 1.5 mm had no complications. In addition, Frederick et al.[12] reported that the microvascular anastomotic coupler system could be used from the size of 1.5 mm and that there was no relation between venous thrombosis and small coupler size. Because of these past reports and the high success rate of our case series, we believe the size of the middle temporal vein is sufficient for safe and reliable microvascular anastomosis.

Nearly half of the specimens showed a middle temporal vein distribution pattern of type I. Only the type 2 middle temporal vein could provide two different sets of recipient vessels, but this distribution pattern was observed in only 13 percent of all specimens. Type 3 and type 4 middle temporal veins, which in total accounted for approximately one-fourth of the specimens, could provide only one alternative recipient vessel. These data suggest that the middle temporal vein can provide (at least) one alternative recipient vein for microanastomosis in the temporal region in all cases. However, nearly half of the specimens (47 percent) had a plexus-type middle temporal vein. Especially in female specimens, plexus-type middle temporal vein accounted for a little more than half of the specimens (53 percent), and plexus-type middle temporal vein was significantly more frequent among type 3 and type 4 than among type 1 and type 2 ($p = 0.013$). This means that the more complex distribution patterns are associated with a plexus-type middle temporal vein. A plexus-type middle temporal vein has many branches, and careful dissection and ligation of small branches is required at the time of harvest of the middle temporal vein, especially in female patients or those with a type 3 or type 4 middle temporal vein. It seemed difficult for surgeons to harvest the middle temporal vein because of this plexus type, but the actual branches, which have to be ligated or coagulated, between the mesh-like venous area and the main middle temporal vein trunk were usually two to four in number in the authors' clinical case series. Therefore, dissection of the middle temporal vein entails almost the same procedures as harvesting a recipient vein in another part of the head and neck area, such as the superficial temporal vein or a vein in the neck.

Table 4. Measured Distance between the Middle Temporal Vein and Each Landmark

Point	Definition	Overall (n = 60)		Male (n = 30)		Female (n = 30)	
		Average (mm)	Range (mm)	Average (mm)	Range (mm)	Average (mm)	Range (mm)
A	Distance between the MTV and the bony lateral canthus	52.0 ± 6.5	42–65	55.1 ± 5.7	46–65	49.0 ± 5.8	42–64
B	Distance between the MTV and the external auditory canal	12.0 ± 4.6	5–22	12.9 ± 4.4	6–22	11.2 ± 4.7	4–22
C	Distance between the upper border of the zygomatic arch and the point at which the MTV joins the STV	12.7 ± 6.6	−2–25	12.3 ± 7.5	−2–25	13.1 ± 5.6	3–25
D	Distance between the upper border of the external auditory canal and the point at which the MTV joins the STV	6.5 ± 5.5	−3–18	6.7 ± 5.2	−2–18	6.4 ± 6.0	−3–18
E	Distance between the point at which the MTV penetrates the superficial layer of the deep temporal fascia and the point that the MTV joins the STV	7.7 ± 3.9	1–19	1–17	7.3 ± 4.2	8.1 ± 3.7	3–19
F	Distance between the MTV and the temporal branch of the facial nerve	13.1 ± 4.1	7–24	13.6 ± 4.7	7–24	12.6 ± 3.4	8–21

MTV, middle temporal vein; STV, superficial temporal vein.

There are two ways of localizing the middle temporal vein using specific landmarks, as shown in Figures 2 and 3. The first method is to use a line between the two bony landmarks (e.g., the bony lateral canthus and the external auditory canal) in the temporal area. The middle temporal vein runs approximately along a line between a point 52 mm lateral from the bony lateral canthus and a point 12 mm medial from the external auditory canal. To identify the middle temporal vein in the temporal area, an incision along this line to the superficial layer of the deep temporal fascia is recommended, which should reveal the middle temporal vein in the temporal fat pad underneath this incision. The second method is to use the superficial temporal vein–middle temporal vein junction to identify the middle temporal vein. A previous detailed report on the superficial temporal vein[13] suggested that it could be easily dissected in the subcutaneous region adjacent to the tragus. According to our study, the superficial temporal vein–middle temporal vein junction is an average of 13 mm below the upper border of the zygomatic arch or 7 mm below the upper border of the external auditory canal. After identifying the superficial temporal vein–middle temporal vein junction, the middle temporal vein runs over the temporal bone and superficial layer of the deep temporal fascia (mean, 8 mm upward) and penetrates the fascia to run within the temporal fat pad. With these landmarks, surgeons could reduce unnecessary incisions, dissection of the superficial fat pad, and sacrifice of the middle temporal vein in clinical practice, which could cause temporal hollowing secondary to the fat necrosis of the temporal area. In addition, because the middle temporal vein and the superficial temporal vein have a common trunk to each other, if a surgeon intended to use the middle temporal vein in a clinical situation, the surgeon should identify the existence and caliber of the middle temporal vein before dissecting the superficial temporal vein far back to the proximal side. If the middle temporal vein has sufficient size for use as an alternative vein, the surgeon should avoid excessive dissection of the superficial temporal vein, because dissection to the proximal side of the superficial temporal vein raises the possibility of damaging the superficial temporal vein–middle temporal vein junction, which would limit the ability to use the middle temporal vein.

An understanding of the relationship between the middle temporal vein and the temporal branch of the facial nerve is important for surgery in this area. The temporal branch of the facial nerve passes upward anterior to the middle

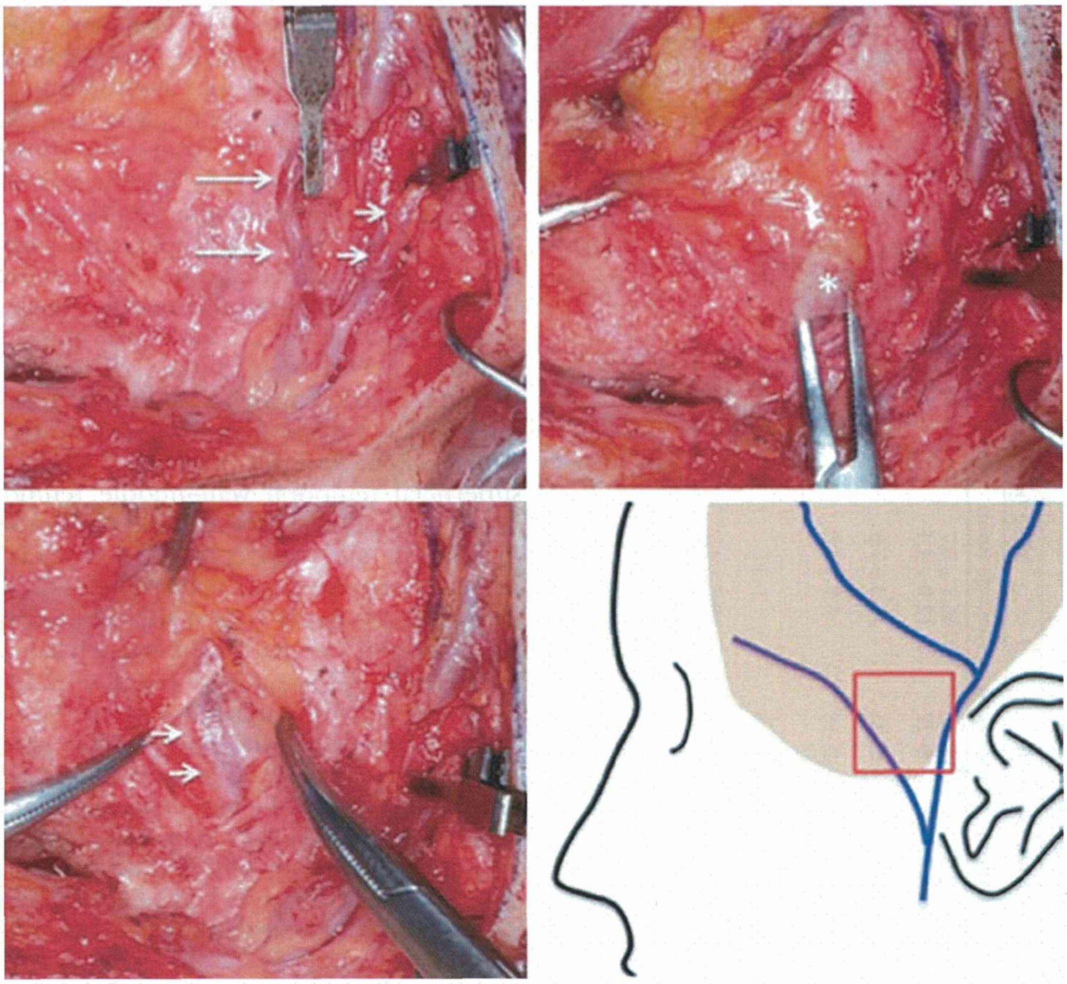

Fig. 7. A clinical case of skull-base reconstruction using the middle temporal vein and superficial temporal vein as recipient vessels. (*Above, left*) *Small arrows* indicate the superficial temporal vein and *long arrows* indicate the superficial temporal artery in the temporal area. (*Above, right*) The *asterisk* indicates the superficial layer of the deep temporal fascia. A mosquito forceps was inserted below the fascia. (*Below, left*) After incision of the fascia. The *arrows* indicate the middle temporal vein in the temporal fat pad below the superficial layer of the deep temporal fascia.

temporal vein, and the temporal branch and the middle temporal vein exist in different layers of the temporal area. Furthermore, these two structures are separated by the superficial layer of the deep temporal fascia. During dissection, particular care should be taken to avoid damaging the temporal branch of the facial nerve. A consecutive dissection study revealed that the distance between the middle temporal vein and the temporal branch of the facial nerve was approximately 13 mm. In addition, there was no significant difference between male and female specimens in this parameter. The distance between the middle temporal vein and the facial nerve and the fact that these structures existed in the different layers translates into a very low probability of damaging the facial nerve if careful dissection of the middle temporal vein is performed.

The main trunk of the middle temporal vein lies in the temporal fat pad, between the superficial and deep layers of the deep temporal fascia, and the middle temporal vein provides venous drainage of the middle layer of the temporal area. In all specimens, the middle temporal vein arose from the subcutaneous fat layer of the lateral canthus area and pierced the superficial layer of the deep temporal fascia (Fig. 8, *above, left*). It then distributed to the superficial fat pad of the temporal region (Fig. 8, *above, right*). The middle temporal vein also provides venous

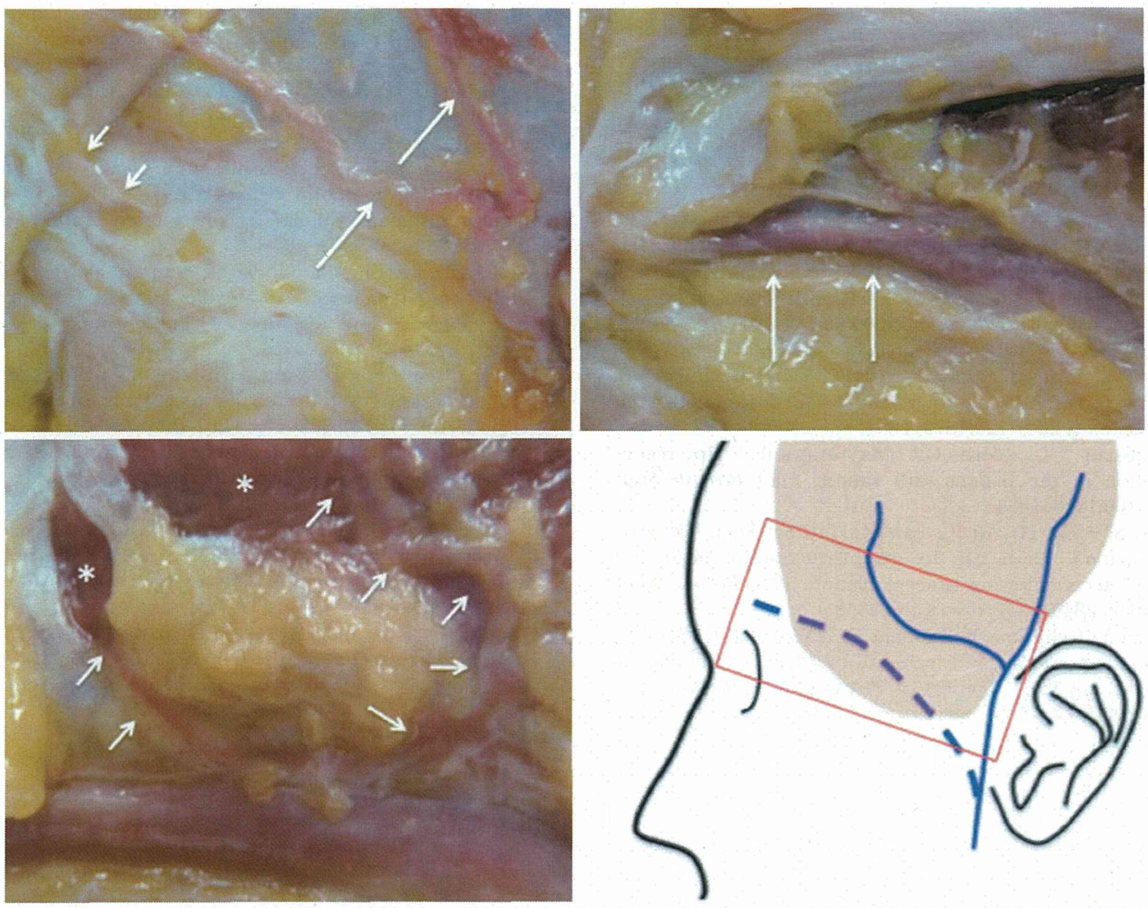

Fig. 8. Relationship between the middle temporal vein and surrounding structures. (*Above, left*) *Small arrows* indicate the middle temporal vein arising from subcutaneous tissue and penetrating the superficial layer of the deep temporal fascia. *Long arrows* indicate that the superficial temporal vein lies above the superficial layer of the deep temporal fascia. (*Above, right*) After removal of the superficial layer of the deep temporal fascia, *arrows* indicate that the major trunk of the middle temporal vein distributes in the temporal fat pad. (*Below, left*) *Arrows* indicate small branches of the middle temporal vein arising from the temporal muscle (*asterisks*) to join the major trunk of the middle temporal vein.

drainage for the surface of the temporal muscle through tiny reticular branches (Fig. 8, *below, left*). The middle temporal vein seems to connect the venous return from the superficial layer (i.e., the subcutaneous fat layer) and the deep layer (i.e., temporal muscle) of the temporal region. These distributions and the spread of the middle temporal vein over multiple layers of the temporal area suggest that it also functions as a bridging vein between the superficial layer (subcutaneous layer) and the deep layer (temporal muscle). The middle temporal vein functions as an inherent venous drainage system of the middle layer of the temporal region but might also serve as an alternative bypass in cases in which the drainage system in a different layer (i.e., a superficial temporal vein or deep temporal vein) has been damaged or obstructed.

CONCLUSIONS

The middle temporal vein can provide one recipient vein of adequate caliber for microvascular anastomosis in the temporal region. In addition, the middle temporal vein can be easily localized by means of incision to the superficial layer of the deep temporal fascia or, conversely, from the superficial temporal vein according to the landmarks described in this study. Because of the small branches around the middle temporal vein, surgeons should perform dissection with care to avoid damaging the temporal branch of the facial nerve.

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REFERENCES

1. Shimizu F, Lin MP, Ellabban M, Evans GR, Cheng MH. Superficial temporal vessels as a reserve recipient site for microvascular head and neck reconstruction in vessel-depleted neck. *Ann Plast Surg.* 2009;62:134–138.
2. Hansen SL, Foster RD, Dosanjh AS, Mathes SJ, Hoffman WY, Leon P. Superficial temporal artery and vein as recipient vessels for facial and scalp microsurgical reconstruction. *Plast Reconstr Surg.* 2007;120:1879–1884.
3. Hussussian CJ, Reece GP. Microsurgical scalp reconstruction in the patient with cancer. *Plast Reconstr Surg.* 2002;109:1828–1834.
4. Shieh SJ, Chiu HY, Yu JC, Pan SC, Tsai ST, Shen CL. Free anterolateral thigh flap for reconstruction of head and neck defects following cancer ablation. *Plast Reconstr Surg.* 2000;105:2349–2357; discussion 2358.
5. Kimata Y, Uchiyama K, Ebihara S, Nakatsuka T, Harii K. Anatomic variations and technical problems of the anterolateral thigh flap: A report of 74 cases. *Plast Reconstr Surg.* 1998;102:1517–1523.
6. Alan Turner MJ, Smith WP. Double venous anastomosis for the radial artery forearm flap: Improving success and minimising morbidity. *J Craniomaxillofac Surg.* 2009;37:253–257.
7. Langdon JD, Mahadev V. Face and scalp: Vascular supply and lymphatic drainage. In: Standring S, ed. *Gray's Anatomy.* 39th ed. London: Elsevier; 2005:509–512.
8. Yano T, Tanaka K, Iida H, Kishimoto S, Okazaki M. Usability of the middle temporal vein as a recipient vessel for free tissue transfer in skull-base reconstruction. *Ann Plast Surg.* 2012;68:286–289.
9. Wolff KD, Kesting M, Mücke T, Rau A, Hölzle F. Thiel embalming technique: A valuable method for microvascular exercise and teaching of flap raising. *Microsurgery* 2008;28:273–278.
10. Hong JP, Koshima I. Using perforators as recipient vessels (supermicrosurgery) for free flap reconstruction of the knee region. *Ann Plast Surg.* 2010;64:291–293.
11. Upton J, Guo L. Pediatric free tissue transfer: A 29-year experience with 433 transfers. *Plast Reconstr Surg.* 2008;121:1725–1737.
12. Frederick JW, Sweeny L, Carroll WR, Rosenthal EL. Microvascular anastomotic coupler assessment in head and neck reconstruction. *Otolaryngol Head Neck Surg.* 2013;149:67–70.
13. Imanishi N, Nakajima H, Minabe T, Chang H, Asio S. Venous drainage architecture of the temporal and parietal regions: Anatomy of the superficial temporal artery and vein. *Plast Reconstr Surg.* 2002;109:2197–2203.