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Outcomes of Venous End-to-Side Microvascular Anastomoses of the Head and Neck

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Objectives/Hypothesis: The literature on outcomes of end-to-side (ETS) anastomoses for microvascular reconstruction of the head and neck is limited. This series reviews ETS in free tissue transfer (FTT) across multiple institutions to better understand their usage and associated outcomes.

Study Design: Retrospective review of 2482 consecutive patients across three tertiary institutions.

Methods: Adult patients (> 18) who received a FTT from 2006 to 2019 were included.

Results: Two hundred and twenty-one FTT were identified as requiring at least one ETS anastomosis. These ETS cases had a failure rate of 11.2% in comparison to 3.8% in a cohort of end-to-end (ETE) cases ($P < .001$). ETS cases were significantly more likely to have a prior neck dissection ($P < .001$), suggesting the ETS method was utilized in select circumstances. A second ETS anastomosis improved survival of the FTT ($P = .006$), as did utilization of a coupler over suture ($P = .002$). Failure due to venous thrombosis was significantly more common with one ETS anastomosis instead of two ETS anastomoses ($P = .042$).

Conclusions: ETS is effective but is often used as a secondary technique when ETE is not feasible; as such, in this series, ETS was associated with higher failure. A second anastomosis and the use of the coupler for completing the anastomoses were associated with lower rates of failure.

Key Words: Free flap, end to side, end to end, pedicle, free flap failure, microvascular reconstruction, free tissue transfer.

Level of Evidence: 3

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INTRODUCTION

Microvascular free tissue transfer (FTT) is the standard treatment for the reconstruction of large complex head and neck defects. FTT is highly successful, with success rates >95% commonly reported in the literature.[1–3] However, failure frequently results in significant functional and aesthetic morbidity and significantly increases costs and length of stay.[4] The added challenges of subsequent reconstructive procedures are taxing for both the patient and the reconstructive team, with outcomes often falling short of expectations.

Many technical factors contribute to the success of FTT, but the most significant is the quality of the microvascular anastomosis and the geometry of the pedicle. There are a variety of techniques that may be successfully applied for anastomosis, including numerous techniques for arterial suturing and the recent introduction of an arterial coupler. Veins may be sutured or coupled and anastomosed end-to-end (ETE) or end-to-side (ETS). An ETE anastomosis, in which the vessel lumens are placed in parallel to each other, is preferred by many surgeons. The ETS technique is defined as securing the FTT vein in a perpendicular fashion to the side wall of the recipient vein. Few studies have evaluated the outcomes of ETS in head and neck microvascular reconstruction, but the literature suggests high success rates for both techniques.[5,6] The choice between using ETE and ETS is determined by surgeon preference, and in our hands, ETS is commonly used as a secondary technique. Notably, the literature reflects that ETS is used more frequently in the vessel-depleted neck.[7] There is a need for a clearer understanding of FTT outcomes with ETS anastomoses as it is

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currently utilized.[5,8] Here we report a large, multi-institutional series of head and neck FTT with ETS anastomoses.

MATERIALS AND METHODS

Following approval by each institution's Institutional Review Board, a retrospective chart review was carried out on all patients who received FTT of the head and neck. Patients who received surgery from 2006 to 2019 were included. A total of 2,482 FTT were reviewed. Six surgeons across two institutions completed the anastomoses. All surgeons typically performed the inset prior to proceeding with the anastomoses, and as a default performed ETE whenever the venous anatomy allowed. Generally, ETS was used as a second-line technique in the setting of a vessel-depleted neck. ETS was defined as an anastomosis requiring a venotomy. The following data were obtained on all patients: age, sex, tumor location, length of stay, history of prior head and neck surgery, and history of prior radiation. Operative notes were reviewed for the type of FTT, type of anastomoses technique (ETE or ETS), recipient vessel, number of anastomoses, and whether the anastomosis was completed with suture or couplers. FTT outcomes (survival or failure) were reviewed, and it was noted if the patient experienced FTT-related complications after the initial surgery such as hematoma, thrombosis, fistula, wound dehiscence, or wound infection.

Statistical Analyses

SPSS software was used for all statistical analyses (IBM Corp., Released 2019, IBM SPSS Statistics for Macintosh, Version 26.0). Univariate analysis was performed using Fischer's exact for categorical binary variables on each anastomosis. Failure in ETS FTT was analyzed using a multivariate logistic regression model with a backward stepwise variable selection based on Akaike information criterion. Statistical significance was defined as $P < .05$.

RESULTS

A total of 2,482 consecutive FTT were reviewed, with a total of 212 patients who underwent 221 FTT requiring at least one ETS anastomosis. Of these 212 patients, 262 ETS anastomoses were completed. Twenty-five FTT failed, and the remaining 197 were successful with an 88.8% success rate. The patients were 62% male (n = 136) and 38% female (n = 82), with an average age of 62 years, ranging from 35 to 91 years. The average length of stay was 6 days. FTT indications and donor sites are shown in Table I. The most common reason for reconstruction was due to squamous cell carcinoma of the oral cavity or oropharynx (n = 105, 48%), and the most common donor site of FTT was the radial forearm (n = 87, 39%). Indication for the procedure and donor site did not predict failure or the presence of complications.

Details of the ETS anastomoses and their relationship to complications are shown in Table II. The most common recipient vessel was the internal jugular vein (n = 219, 84%). Vessel selection did not predict FTT failure or the presence of complication. One venous ETS anastomosis (n = 177, 68%) was more common than two ETS anastomoses (n = 85, 32%). Ischemia time was reviewed on FTT in which the data were recorded (n = 110), with an average of 123 ± 38 minutes: 111 ETS anastomoses with 57 FTT below 120 minutes of ischemia time and 54 FTT above 120 minutes of ischemia time. Ischemia time did not correlate with FTT failure. There was no association between development of complications with the number of anastomoses, recipient vessels, coupler or suture usage, or ischemia time.

The failure rate of FTT with one ETS anastomoses was 13% (n = 23/177), whereas the failure rate with two ETS anastomoses was 2% (n = 2/85) ($P = .006$, odds ratio [OR] 6.2, 95% confidence interval [CI] 1.4–26.9). Usage of couplers (n = 181, 69%) was more frequent than suturing the anastomoses (n = 81, 31%). Utilizing the suture technique had a significantly higher failure rate of 19% (n = 15/81) as compared to using couplers, which had a 6% (n = 10/181) failure rate ($P = .002$, OR 3.9, 95% CI 1.6–9.1). Neither prior radiation to the neck nor prior surgery to the neck correlated with a specific number of ETS anastomoses. The use of suture for the anastomosis was found to be significantly more common in those with prior surgery to the neck (n = 28, 35%) ($P = .047$, OR 1.9, 95% CI 1.0–3.3), but not prior radiation (n = 40; 22%) ($P = .480$, OR 1.2). Salivary fistula was more common utilizing suture (56%, n = 9/16) over couplers (43%, n = 7/16) ($P = .046$, OR 3.1, 95% CI 1.1–8.7) (Table III).

Select comorbidities and complications were reviewed for impact on the number of anastomoses and technique of completing the anastomosis. There were a total of 106 complications across 65 patients (29% of patients) (Table III). Fifteen venous thromboses were noted and were found to be significantly more common in FTT with one ETS (93%, n = 14/15) as compared to two ETS (6%, n = 1/15) ($P = .042$, OR 7.2, 95% CI 9–55.8) (Table III). The incidence of arterial thrombosis, hematoma, wound dehiscence, and wound infections did not correlate with the number of anastomoses or methods used for the anastomosis (usage of couplers or suture).

Multivariate analysis of prior radiation, prior neck surgery, usage of a single ETS anastomosis, and the suture was performed to predict failure. The multivariable logistic regression model shows that FTT with one ETS anastomosis and utilizing suture were more likely to fail, with a P value of $P = .030$ (OR 5.2) and $P = .012$ (OR 3.1), respectively. Prior surgery to the neck trended toward significance in predicting failure ($P = .081$), whereas prior radiation was not found to be significant ($P = .59$) (Table IV).

The ETE cohort was compared to the ETS cohort. The ETE cohort was significantly less likely to have a prior neck dissection: 9% in the ETE group compared to 26% in the ETS group, $P < .001$ (OR 3.8, 95% CI 2.4–6.0). Prior radiation was similar between groups: 30% in the ETE cohort compared to 34% in the ETS cohort ($P = .22$). Failure rate in the ETE cohort was 3.4% as compared to 11.2% seen in the ETS cohort ($P < .001$, OR 2.7, 95% CI 2.0–5.2). The outcomes of ETE and ETS cohorts were then evaluated on several independent metrics to understand this difference: prior neck surgery and failures attributed to venous congestion. The ETE primary surgery cohort had a 2.5% failure rate (n = 52/2049), which was significantly lower than the ETS primary surgery

TABLE I.
Univariate Analysis of Free Tissue Transfer (FTT) Failure and Presence of Complications by Indication and Donor Site.

		FTT Failure (Rate)		One or More Complication	
	n (%)	n (%)	*P* Value	n	*P* Value
Indication					
SCC oral cavity/oropharynx	105 (48)	11 (10)	1.0	32	.773
SCC larynx	34 (15)	6 (18)	.225	11	1.0
SCC hypopharynx	7 (3)	1 (14)	.558	3	.682
SCC maxilla	9 (4)	2 (22)	.254	3	1.0
SCC cheek/nose/lip/facial skin	13 (6)	0 (0)	.370	1	.067
Osteoradionecrosis	21 (10%)	1 (5)	.483	6	1.0
Other	32 (15)	3 (9)	1.0	14	.149
Donor site					
Anterolateral thigh	62 (28)	5 (8)	.463	21	.505
Fibula	41 (19)	6 (15)	.406	17	.124
Radial forearm	87 (39)	10 (11)	1.0	20	.041
Other	31 (14)	3 (10)	1.0	12	.298

SCC = squamous cell carcinoma.

TABLE II.
Univariate Analysis of End-to-Side (ETS) Anastomoses: Free Tissue Transfer (FTT) Failure and Presence of Complications.

		FTT Failure (Rate)		One or More Complications	
	n (%)	n (%)	*P* Value	n	*P* Value
1 Venous ETS anastomosis	177 (68)	23 (13)	.006	60	.115
2 Venous ETS anastomosis	85 (32)	2 (2)	.006	20	.115
Recipient vessel: IJV	219 (84)	21 (10)	1.0	71	.151
Recipient vessel: EJV	19 (7)	1 (5)	1.0	3	.198
Recipient vessel: Other	24 (9)	3 (13)	.712	6	.646
Ischemia time: < 120 min	57 (22)	2 (4)	.263	17	.082
Ischemia time: ≥ 120 min	54 (21)	5 (9)	.263	25	.082
Coupler	181 (69)	10 (6)	.002	53	.562
Suture	81 (31)	15 (19)	.002	27	.562

EJV = External Jugular Vein; IJV = Internal Jugular Vein.

TABLE III.
Univariate Analysis of End-to-Side (ETS) Anastomoses: Select Comorbidities and Complications.

	1 ETS	2 ETS		Coupler	Suture	
	n = 177, n (%)	n = 85, n (%)	*P* Value	n = 181, n (%)	n = 81, n (%)	*P* Value
Prior head and neck radiation	64 (36)	24 (28)	.212	58 (32)	30 (37)	.480
Prior neck surgery	49 (28)	19 (22)	.452	40 (22)	28 (35)	.047
Venous thrombosis	14 (8)	1 (1)	.042	9 (5)	6 (7)	.565
Arterial thrombosis	4 (2)	1 (1)	1.0	3 (2)	2 (2)	.646
Fistula	14 (8)	2 (2)	.100	7 (4)	9 (11)	.046
Hematoma	15 (8)	2 (2)	.065	14 (7)	3 (4)	.285
Wound dehiscence	24 (14)	5 (6)	.091	24 (13)	5 (6)	.134
Wound infection	14 (8)	10 (12)	.361	17 (9)	7 (9)	1.0

cohort failure rate of 8.5% (n = 14/164) ($P < .001$, OR 0.3, 95% CI 0.2–0.5). Similarly, the failure rate in the ETE group with prior neck dissection was 11.8% (n = 25/212) was also lower compared to the ETS group with prior neck dissection which was 17.5% (n = 11/57). This did not reach statistical significance ($P = .18$, OR 0.6, 95% CI

TABLE IV.
Multivariate Analysis of End-to-Side (ETS) Anastomoses to Predict Failure.

	Odds Ratio	Correlation Coefficient (95% CI)	*P* Value
Prior head and neck radiation	0.8	0.3–2.0	.585
Prior neck dissection	2.3	0.9–5.7	.081
1 Venous ETS anastomosis	5.2	1.2–23.2	.030
Suture	3.1	1.3–7.4	.012

CI = confidence interval.

0.3–1.2). Finally, ETE versus ETS were compared for failure attributed to venous compromise. Thirty-six percent (n = 9/25) of the ETS and 19% (n = 15/77) of the ETE cohort failed due to venous congestion, which did not reach statistical significance (P = .11, OR 2.3, 95% CI 0.9–6.4).

DISCUSSION

ETS venous anastomosis has been described for FTT in the head and neck[6]; however, FTT has evolved in the past two decades with widespread use of the coupler, improved success rates, and greater dissemination of technical knowledge.[9, 10] Although previous studies on ETS reviewed limited cohorts, they found ETE versus ETS to have similar FTT success rates.[5, 6, 8] In our practices, ETS is used when ETE is not reasonably possible, and therefore, primarily represents a secondary technique. ETS anastomosis may be utilized in a variety of scenarios, most commonly the vessel-depleted neck, which can occur following previous radiation therapy or surgery.[11] In this series, the use of ETS over ETE was associated with prior neck dissection ($P < .001$) reflecting the vessel-depleted neck. The overall failure rate in the ETS cohort (11.2%) was higher than that of the ETE cohort (3.8%, $P < .001$). We suspect that this also reflects its use as a secondary technique in more challenging cases. Determination of the exact features of the case resulting in a vessel-depleted neck leading to use of ETS may require a prospective approach to capture accurate data from each case. Further, we sought to evaluate the risk of venous failure according to the technique for venous anastomosis, and there was no significant difference found between the ETS and ETE cohorts (P = .11). This also suggests that although there was an increased rate of failure in ETS cases, the reason for FTT failure was likely multifactorial in nature and not entirely due to the type of anastomoses.

We also sought to evaluate the significance of a second anastomosis when ETS was performed. Two ETS anastomoses were associated with a significantly decreased incidence of FTT failure (2%) as compared to single ETS (13%, P = .006). Performing two venous anastomoses has been a topic of debate. Two venous anastomoses have been postulated to be advantageous due to providing additional outflow, which can compensate for a compressed or kinked vein.[12] This is thought to protect against congestion and mitigate the development of stasis and subsequent FTT compromise. Turner and Smith reported 106 radial forearm FTT using two ETS; they demonstrated favorable outcomes with success rates >99%.[13] A meta-analysis released in 2015 strongly supported the use of two venous anastomoses to reduce FTT failure and thrombosis: of 6,842 FTT reviewed, they report a failure rate of 3.1% for a single anastomosis and 1.3% for double anastomoses.[14] In this series, the majority of failures were those with one ETS anastomosis. Retrospectively determining the rationale and necessity of a second anastomosis is challenging, but the findings do suggest that if a second ETS is possible, there may be benefit.

The ETS cohort was analyzed by coupler versus sutured anastomosis showing increased success rates with use of the coupler. Consistent with other institutions, our groups have adopted the venous coupler as first choice for venous anastomosis. The vein was typically sutured only in cases where coupling was suboptimal or not possible. Authors have argued suture anastomosis is more prone to inadequate eversion of the vessel, intralumenal adventitia exposure, and vessel leaks compared to the coupler.[15] Yap et al. reviewed venous thrombosis rates between utilizing couplers and suture for the anastomoses, and reported reduced venous thrombosis rates when coupler were utilized for the venous anastomosis.[16] The authors attributed this to decreased technical errors as compared to sutured anastomoses. It is our preference to perform microvenous anastomosis with the coupler. In general, we have sutured when the coupler is not possible: at times trying the coupler first and if not able to place it, the vein was then sewn. It has been our experience that after prior neck dissection the jugular vein is less pliable. Using the coupler requires significant mobilization of the jugular vein above and below the planned ETS and also requires significantly more thinning of the adhesive scar from the wall to allow the venotomy to be easily everted over the coupler spikes. When this is not possible or acceptable, then suturing the ETS is necessary.

There are several limitations of this study, including its retrospective nature and relatively small sample size for ETS cases. Further, ETS was utilized as a secondary technique that makes direct comparison between the groups limited. Further study in a prospective setting would be necessary to fully determine the precise effects of ETS on flap success.

CONCLUSION

ETS is an effective technique and in this series was used more often as a secondary technique in the vessel-depleted neck. ETS was associated with higher failure that ETE, but use of the coupler and a second anastomosis were associated with lower failure rates.

BIBLIOGRAPHY

1. Frederick JW, Sweeny L, Carroll WR, Peters GE, Rosenthal EL. Outcomes in head and neck reconstruction by surgical site and donor site. *Laryngoscope* 2013;123:1612–1617.
2. Juh JD, Sercarz JA, Aaraj YA, et al. Analysis of outcome and complications in 400 cases of microvascular head and neck reconstruction. *Arch Otolaryngol Head Neck Surg* 2004;130:962–966.
3. Haughey BH, Wilson E, Kluwe L, et al. Free flap reconstruction of the head and neck: analysis of 241 cases. *Otolaryngol Head Neck Surg* 2001;125: 10–17.
4. Ryan M, Hochman M. Length of stay after free flap reconstruction of the head and neck. *Laryngoscope* 2000;110:210–216.
5. Francis DO, Stern RE, Zeitler D, Izzard M, Futran ND. Analysis of free flap viability based on recipient vein selection. *Head Neck* 2009;31:1354–1359.
6. Piazza C, Taglietti V, Paderno A, Nicolai P. End-to-end versus end-to-side venous microanastomoses in head and neck reconstruction. *Eur Arch Otorhinolaryngol* 2014;271:157–162.
7. Katou F, Echigo S, Ito M, Shirai N, Ohtani H, Motegi K. Reliability of internal jugular vein in oral microvaseular reconstruction. *Oral Surg Oral Med Oral Pathol* 1998;86:529–533.
8. Ueda K, Harii K, Nakatsuka T, Asato H, Yamada A. Comparison of end-to-end and end-to-side venous anastomosis in free-tissue transfer following resection of head and neck tumors. *Microsurgery* 1996;17:146–149.
9. Ardehali B, Morritt AN, Jain A. Systematic review: anastomotic microvascular device. *J Plast Reconstr Aesthet Surg* 2014;67:752–755.
10. Wang WM, Huang L, Gao X, Yuan YX, Chen XQ, Jian XC. Use of a microvascular coupler device for end-to-side venous anastomosis in oral and maxillofacial reconstruction. *Int J Oral Maxillofac Surg* 2018;47: 1263–1267.
11. Alam DS, Khariwala SS. Technical considerations in patients requiring a second microvascular free flap in the head and neck. *Arch Otolaryngol Head Neck Surg* 2009;135:268–273.
12. Yamamoto Y, Nohira K, Kuwahara H, Sekido M, Furukawa H, Sugihara T. Superiority of end-to-side anastomosis with the internal jugular vein: the experience of 80 cases in head and neck microsurgical reconstruction. *Br J Plast Surg* 1999;52:88–91.
13. Turner M, Smith W. Double venous anastomosis for the radial artery forearm flap. Improving success and minimising morbidity. *J Craniomaxillofac Surg* 2009;37:253–257.
14. Riot S, Herlin C, Mojallal A, et al. A systematic review and meta-analysis of double venous anastomosis in free flaps. *Plast Reconstr Surg* 2015;136: 1299–1311.
15. Chernichenko N, Ross DA, Shin J, Sasaki CT, Ariyan S. End-to-side venous anastomosis with an anastomotic coupling device for microvascular free-tissue transfer in head and neck reconstruction. *Laryngoscope* 2008;118: 2146–2150.
16. Yap LH, Constantinides J, Butler CE. Venous thrombosis in coupled versus sutured microvascular anastomoses. *Ann Plast Surg* 2006;57:666–669.