Review Article

Medial sural artery perforator flap—indications, tips and pitfalls: a narrative review

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Background and Objective: Following the description of the medial sural artery free flap by Cavadas *et al.*, the MSAP free flap is proving to be a useful tool for the head and neck reconstructive surgeon.

Methods: The authors review the available literature for MSAP free flaps in particular related to oral cavity reconstruction and share their technique and experience with the MSAP free flap reconstruction of oral cavity defects. Twenty nine prospective cases of oral cavity reconstruction with MSAP free flaps between October 2015 and May 2020 in a tertiary referral centre are discussed.

Key Content and Findings: The principle advantages of the MSAP flap include the favourable thickness (mean 9.29 mm), pliability, pedicle length (mean 12.4 cm) and favourable donor site (primary closure 93%). The mean number of perforators was 1.4. The mean vessel diameter for the artery was 1.43 mm and vein 3.42 mm respectively. The overall complication rate was 17% (5/29 cases). Key challenges include care during flap inset and avoidance of perforator twisting. Implantable dopplers are also recommended for postoperative flap monitoring. Useful technical tips and the recognised challenges in the literature associated with this flap are discussed.

Conclusions: Overall, the MSAP flap can be a useful tool in the armamentarium of the head and neck reconstructive surgeon for oral cavity reconstruction.

Keywords: Free flap; perforator; sural artery; reconstruction; microvascular

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Background

The introduction of free flaps and microvascular surgery has significantly improved the reconstructive options of complex oncological defects in the head and neck. Early free flaps were based on named arterial pedicles to allow musculocutaneous, fasciocutaneous or composite tissue to be used in reconstruction.

Current workhorse flaps for soft tissue reconstruction in the oral cavity include the radial forearm free flap (RFFF) and anterolateral thigh flap (ALT) free flaps (1-4).

In 1975, Taylor and Daniel (5) were the first to propose the posterior calf as a versatile option for perforator-based free flap reconstruction. G. Ian Taylor's work in 1987 described a concept, of mapping angiosomes throughout the body that subsequently led to the development and use of perforator flaps (6). Consequently, Montegut and Allen (7) followed by Hallock (8) described the topographical anatomy of the posterior calf laying the foundation for the medial sural artery perforator (MSAP) flap.

Using the perforator concept, Cavadas *et al.* (9) performed the first clinical series of six MSAP flaps for

Table 1 The inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Case reports, Case series, case -control studies, cohort studies, randomised controlled trials	Reviews, letters, conference abstracts
Free flap reconstruction for head and neck cancer	Non head and neck cancer free flap reconstruction
Medial sural artery perforator flap	Flaps other than medial sural artery perforator flap
Human studies	Animal studies
English language	Non English language

reconstruction of lower limb defects in 2001. The principal advantages of this fascio-cutaneous free flap include a thin, pliable nature (10), with adequate pedicle length and a well-hidden donor site that can often be closed primarily with minimal functional deficit (9). Chalmers *et al.* (11) commented the MSAP flap can provide a reliable alternative to the workhorse flaps in intra-oral reconstruction (11).

The senior authors have been early adopters of this flap in oral cavity reconstruction and would like to share their experience, technique, tips and pitfalls for the benefit of fellow colleagues.

Patient and methods

The inclusion and exclusion criteria were set prior to searching. A literature search was conducted on PubMed/MEDLINE. The search term "medial sural artery perforator" was used. No restriction was placed on date of publication. The full list of search results was reviewed and the titles and abstracts of all papers assessed. Those papers that met all of the inclusion criteria were selected. Furthermore, the papers selected were then also hand searched for additional literature that met the inclusion criteria and subsequently included (*Table 1*).

Prospective data for patients that underwent head and neck reconstruction with MSAP free flaps at Queen Victoria Hospital (a tertiary referral centre) was collected between October 2015 – May 2020. The data points collected included patient hospital number, operation date, resection site, flap size—length and width, number of perforators, arterial diameter, venous diameter, coupler size used, pedicle length, closure method—primary closure or skin graft and complications. The microvascular surgery involved hand sewn anastomosis for the artery and a coupler device for the vein.

Anatomy

The medial sural artery arises from the popliteal artery within the popliteal fossa and runs within the medial head of the gastrocnemius muscle. The course of the main artery largely remains longitudinal between the muscle fibres of the gastrocnemius before dividing into a medial and lateral branch. The overlying fascial plexus and skin perforators are supplied via these musculocutaneous branches. Four different types of intra-muscular branching patterns of MSA have been reported by Dusseldorp (12): Type I-single branch (31%), type IIA-dual branching pattern with high take-off point above the tibial plateau (35%), type IIB-dual branching pattern with low take-off point below the tibial plateau (24%) and type III-3 or more branches (10%) (12).

The number of perforators ranges from 1 to 5 (13). The average distance from the popliteal crease to the first and second perforators is about 11.8 and 17 cm respectively (9). Kim *et al.* (14) reported that the first main perforator can be identified within a 2 cm radius, 8 cm from a line connecting the mid popliteal fossa to the medial malleolus. Most of the dominant perforators are detected 8–10 cm distal to the popliteal crease along the connection line of its midpoint and the medial ankle (15). Kao *et al.* (16) noted that no perforator was found either less than 6 cm or more than 18cm below the popliteal crease.

The calibre of the medial sural artery has been reported on average between 1 (17)–3 mm (10) and the accompanying venae comitantes tend to be more voluminous 2–6 mm (11). Pedicle length is between 8-16 cm (16) and thickness is 4.2 (18)–8.4 mm (10).

Technique

The authors recommend pre-operative identification of perforators in the ward or out-patient setting using a handheld ultrasound Doppler probe 8–10 Mhz. This is best performed with leg abducted, knee flexed and externally rotated (frog's legs position) as would be the position intra-operatively. Majority of the perforators will be located between 8–12 cm from the mid-popliteal fossa and 1–2 cm inside the line connecting the mid-popliteal fossa to the medial malleolus (19). Once the cutaneous perforators have been identified, the markings can be secured with a clear film adhesive dressing (*Figure 1*).

The position of the leg as described above can be secured

Figure 1 Surface markings: Straight line extending vertically downwards from mid-popliteal crease to Achilles' tendon. Diagonal line extending from the mid-popliteal crease to medial malleolus.

Figure 2 Doppler markings.

Figure 3 Initial skin incision.

intra-operatively utilising a vacuum bean bag with padding underneath the fibula head to avoid compression injury to the common peroneal nerve. The operating surgeon is positioned on the opposite side of the operating table. A split leg table has been described (20) for the harvest but the authors do not feel this is absolutely necessary. Flap harvest is performed simultaneously as ablation in being performed.

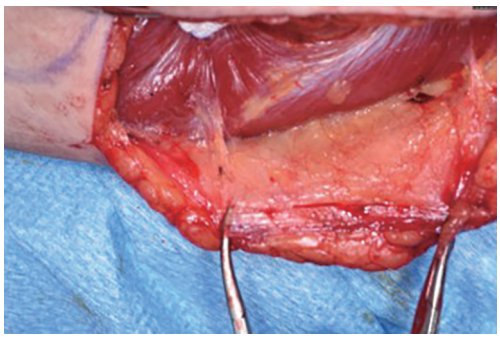

Figure 4 Identification of perforators.

Surface markings

Straight line extending vertically downwards from mid-popliteal crease to Achilles' tendon. Diagonal line extending from the mid-popliteal crease to medial malleolus (*Figure 2*).

Use of loupes magnification (2.5–4×) is recommended. The skin incision is made in a curvilinear fashion anterior to the diagonal skin surface marking 8 to 12 cm below the popliteal crease (*Figure 3*). Dissection proceeds in a sub-fascial plane and care should be taken whilst approaching the perforator vessels. The most distal perforators must be identified first and the dissection proceed from a distal to proximal fashion (*Figure 4*). Some perforating vessels can be very small in calibre and care must be taken to preserve these, whilst continuing the dissection proximally. All perforators should be preserved at this stage regardless of calibre until the dissection is complete. Use of cotton pledgets, vascular loops and bipolar diathermy can aid dissection. Once the pedicle of the medial sural artery is reached, the vessel usually runs in the direction of the gastrocnemius muscle fibres and a muscle splitting approach can be employed in the majority of the dissection.

As the dissection proceeds proximally, a relatively large side branch to the medial gastrocnemius will be identified. This should be sacrificed as the vessel calibre does seem to increase beyond this. Once the required pedicle length is reached, the dissection is completed prior to reaching the popliteal fossa. The required skin paddle can then be designed based on the perforator anatomy. Only then should any non-viable perforators be sacrificed. Following designing of the skin paddle, the authors recommend marking of the dissected perforator and pedicle with ink to avoid twisting during inset or completion of the skin paddle harvest (*Figure 5*).

Donor site can be closed primarily in the majority of cases.

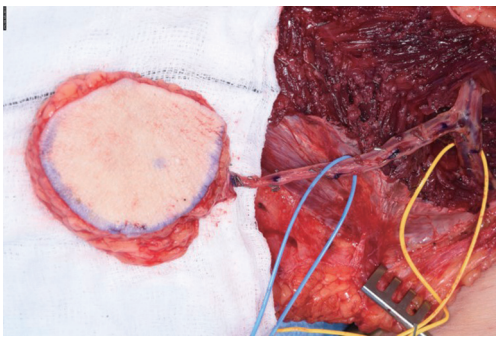

Figure 5 Branch to medial gastrocnemius identified.

Figure 6 MSAP flap reconstructing floor of mouth.

Table 2 Flap parameters

	Range	Average
Length (cm)	5–9	6.39
Width (cm)	4–6	4.98
Flap thickness (mm)	4–17	9.29
No perforators	1–2	1.45
Arterial diameter (mm)	0.6–2	1.43
Venous diameter (mm)	1–8	3.42
Pedicle length (cm)	8–20	12.4
Primary closure, n (%)	27/29	93.1%
Total complications, n (%)	5/29	17.24%
Flap failure	3/29	10.34%
Donor site wound dehiscence	2/29	6.89%
Recipient wound site dehiscence	0/29	0%

Figure 7 Donor site at 8 weeks.

Results

Our prospective study includes 29 patients, who underwent oral cavity reconstruction with MSAP free flaps at Queen Victoria Hospital between October 2015 and May 2020 (*Table 2*, *Figures 6*,*7*).

- Cases performed at QVH between Oct 2015 – May 2020=29 cases
- 26/29 Flap survival =89.7%
- Average skin paddle size: 6.39 cm × 4.98 cm
- Primary closure achieved in 93.1%
- Average no of perforators: 1.45
- 3 partial/ total flap failures (10.3%):
  - 3 arterial failures
    - 1 early failure at D3
    - 2 late failures at D6 + D7 post op

Discussion

The results from our study show that the MSAP flap can be considered as an alternative for soft tissue reconstruction in the oral cavity. Reasonable size defects in the oral cavity of subsites including floor of mouth, lateral tongue, buccal mucosa amongst others can be reconstructed as demonstrated. Studies show that skin paddles up to 20 cm ×10 cm can be harvested for larger defects (21). A key factor to be considered is the closure of the donor site and

whether primary closure can be achieved. In our study, 6.9% of cases required a STSG for closure of the donor site with a rate of up to 32% described in the literature (19). Donor site dehiscence was reported in two cases (6.89%); the risk of complications for donor sites closed primarily was over five times greater for flap widths greater than 5.75 cm (21). An overall donor site morbidity rate of 1.9% as shown in the 2019 systematic review and meta-analysis performed by Daar (21) shows the MSAP to have a low donor site morbidity rate.

Calibre of the artery has been reported to be quite small and ranges from 1.1 (17) to 3 mm (10). Our study reports the mean arterial diameter and the mean diameter of the accompanying venae comitantes to be 1.43 mm and 3.42 mm respectively. The mean number of perforators in our cohort was 1.45 which is consistent with other reported literature.

In our cohort of oral cavity reconstruction, the success rate was 89.7%. The literature shows success rates with MSAP in intra-oral reconstruction is 75% (22) to 100% (10,11,19,23,24) with the largest series of 129 cases by Deek *et al.* 2020 (25) having a survival rate of 96.1%. In Daar's meta-analysis of 520 cases, there was an overall partial (3.1%) and total flap failure (3.1%) (16 cases) (21). An increased complication rate is reported with the MSAP flap when it used as a chimeric flap (21). The authors feel the number of cases in the presented cohort study is low and with increased experience, the success rate is likely to be higher.

One flap was successfully salvaged at day 1 and underwent a revision of the arterial as well as venous anastomosis. In this case, the perforator was noted to be twisted leading to arterial compromise. Three cases where the flap could not be salvaged were all related to arterial compromise. In 2 patients, the compromise was picked up late on day 6 and day 7 respectively and could be a contributory factor.

Other complications included donor site and skin graft dehiscence (6.7%) with the overall complication rate of 17.24%. A meta-analysis of 504 flaps by Daar *et al.* (21) reveals an overall complication rate of 14.3%. The complication rate for MSAP in oral cavity reconstruction ranges from 10.4–16.7% (1,26,27).

Functional outcomes in our cohort were measure prospectively using the MDADI scale and this showed that all patients obtained good speech and swallow function and did not require prolonged nasogastric/supplementary feeding.

The most obvious advantages of the MSAP flap are the relative thickness of the flap which is favourable for intra-oral reconstruction, good pedicle length and the ability to primarily close the donor site in the majority of cases. The disadvantages are the reduced vessel calibre and variable perforator anatomy. Necrosis of the medial head of the gastrocnemius was reported by Tsou *et al.* (28) although this was not encountered in our series. The authors found an overall higher complication rate with the MSAP flap compared to other workhorse flaps such as RFFF and ALT in the unit. The numbers in the study are low and no doubt, there is a learning curve with this particular flap. Nonetheless, there is a role for this mode of reconstruction in certain situations and would like to share these observations to aid surgeons.

During flap harvest, maintain all perforators until dissection of the pedicle is complete. In our experience, dissection of the musculocutaneous perforators was often easier that ALT flap due to orientation of the perforator in the direction of the muscle fibres. Occasionally, the flap design may be transverse on the calf depending on the perforator orientation. A useful tip is also to mark the perforator and pedicle with ink prior to outlining the skin paddle to help avoid twisting during harvest and inset as this was a key cause of flap compromise in the cohort. Therefore, utmost care must be taken during flap inset. With regards to the most suitable donor artery in the neck, the superior thyroid artery is preferable this provides a better size match when compared to the facial artery. Moreover, there is a tendency of the small calibre MSAP artery to undergo spasm and this may be exacerbated by a 'big into small' situation. There may also be a lag period of around 5–10 minutes following release of the clamps for the flap to 'pick up' due to vessel spasm and some patience during this period is required. The use of implantable dopplers is recommended to monitor flap postoperatively as this could help pick up arterial compromise sooner should this be the case.

Conclusion

The authors found the MSAP flap can be a useful tool in the armamentarium of the head and neck surgeon for reconstruction of oral cavity defects, whilst keeping in mind the recognized challenges associated with this flap.

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Footnote

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