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Review

Dorsal Metatarsal Artery Perforator (DMtAP) flap Reconstruction of the Foot – A Review

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ABSTRACT

The dorsal metatarsal artery perforator (DMtAP) flap is a relatively new flap in the reconstructive armamentarium. Our understanding has only recently increased with data from cadaveric dissections, which have increased our understanding of the DMtAP system of the forefoot. Sporadic reports in the literature have been published regarding its various uses for defects around the forefoot. This review aims to summarize the reports and results thus far in the literature and bring together the anatomical evidence of DMtAPs in the forefoot. We also demonstrate our experience in raising a DMtAP flap and its potential use for reconstruction of the forefoot after skin cancer surgery. This is a versatile and reliable flap.

Introduction

Our understanding of the dorsal metatarsal artery perforator (DMtAP) flap has seen improvements recently, with several cadaveric studies investigating the blood supply and perforators of the forefoot. Although the DMtAP was first reported by Quaba and colleagues in 1997, there were no cadaveric

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studies till 2014. Most reports in the literature have been of the first DMtAP, and the use of other DMtAPs has not been reported. In fact, there is a paucity of its use in reconstructing the forefoot. Other reports, both pedicled and free use, of the DMtA main pedicle have been described, but a relatively fewer number have described the use of this perforator-based flap which has distinct advantages including a quicker dissection obviating the need for any intramuscular dissection and hence decreasing donor site morbidity.

Forefoot reconstruction can be difficult as individual toe webspace and extensor tendon exposure must be taken into consideration. The first reported use of the DMtAP flap was as a turnover adipofascial flap in 1991.[1] Bharathwaj and Quaba reported the use of the first DMtAP flap as a 90° propeller flap to cover post burns contracture defects of the forefoot with skin grafting of the donor site.[2] The authors report that they had dissected out the perforator from the dorsal metatarsal artery itself, based on a report by Earley and Milner in 1989 where a distally-based adipofascial flap was raised even more distally based on the anastomoses and arborization of vessels between the dorsal metatarsal artery and plantar metatarsal artery which was located at the webspace, which was not a real perforator flap. The DMtAP as described lies more proximally between the metatarsal heads. The vascular anatomy of the foot was studied previously by Yeo et al, and Van Alphen et al were amongst the first to study the vascular anatomy of the forefoot and particularly the DMtAP flap using cadaveric dissections. Analogous to the Quaba flap or dorsal metacarpal artery perforator flap first described in 1990, the dorsal metatarsal artery perforator flap is also a constant perforator which can be used to raise propeller flaps for local coverage.[3]

This article aims to summarize and review the versatility of the DMtAP flap and describe our experience in raising a third DMtAP flap for forefoot defect reconstruction following a wide local excision of a melanoma and sentinel lymph node biopsy.

Materials and methods

Search methods

A list of MeSH terms was made and used to search PubMed, Embase, and Medline sources. Keywords such as ‘dorsal metatarsal artery’, ‘dorsal foot flap’, and ‘dorsal metatarsal artery perforator’ were used. The search was performed by two reviewers who performed the task independent of each other. Articles deemed relevant were then analyzed by our reviewers. The search was specific to this DMtAP flap, and any other dorsum of foot flaps were excluded from this review. Anatomical characteristics of each dorsal metatarsal artery perforator flap and their clinical usage in the literature were presented in two tables (Table 1 and 2).

Selection criteria

Articles deemed relevant were then reviewed, their individual references were also checked, and additional relevant articles included. Articles were analyzed, and relevant data were extracted. A table of results presenting the incidence of the DMtAP, average number of perforators found, maximum perforator size in millimeter, location of perforators, and perfusion size of each perforator (Table 1) is presented in this article. Clinical data such as defect location reconstructed with the DMtAP flap, number of flaps raised in each series, flap size, donor site, degree of rotation, incidence of postoperative venous congestion, and report flap survival rate (Table 2) are also reported.

Data extraction

The articles were reviewed, and the anatomical characteristics were obtained. The articles with clinical relevance were also included. Duplicates and articles describing earlier models with less data were removed from the analysis. Any articles which were not specific to the perforator and described the main artery were excluded as well. Only eight articles were found to fit our inclusion criteria.

Table 1
A summary of DMtAP characteristics in cadaveric dissections reported in the literature.

Pedicle	Incidence of DMtAP	Average number of perforators	Maximum perforator size (mm)	Location of perforators	Methylene blue skin flap perfusion size (cm)	References
1st DMtAP	8/10 16/16	3.9 2-5	0.6 0.5-0.7	n/a Between heads of metatarsals, distal to extensor juncturae	2.16 × 4.76 n/a	Van alphen et al. Yeo et al.
2nd DMtAP	9/10 16/16	4.1 2-5	0.6 0.5-0.7	n/a Between heads of metatarsals, distal to extensor juncturae	2.16 × 4.76 n/a	Van alphen et al. Yeo et al.
3rd DMtAP	9/10 16/16	3.4 2-5	0.7 0.5-0.7	n/a Between heads of metatarsals, distal to extensor juncturae	2.16 × 4.76 n/a	Van alphen et al. Yeo et al.
4th DMtAP	9/10 16/16	3.6 2-5	0.8 0.5-0.7	n/a Between heads of metatarsals, distal to extensor juncturae	2.16 × 4.76 n/a	Van alphen et al. Yeo et al.

Table 2
A summary of the clinical DMtAP flaps reported in the literature.

Pedicle	Defect location	Number of flaps	Flap size (cm)	Donor site	Degree of Rotation (°)	Reported postoperative venous congestion	Flap Survival	References
1st DMtAP	Burns contracture dorsum forefoot 1st to 5th MTPJ	14	5 × 2.5 – 8 × 5	Skin graft	90	3/14	100%	Bharathwaj et al.
	1st MTPJ	1	8 × 4	Skin graft	90	None	100%	Cinpolat et al.
	1) medial and plantar surface of the great toe 2) lateral aspect of great toe	2	3 × 3, 3 × 5	Direct closure	180	None	100%	Hallock et al.
2nd DMtAP	1st webspace	1	8 × 1.5	Direct closure	120	None	100%	Yeo et al.
3rd DMtAP	5th MTPJ, 1st MTPJ, 4th toe	3	5 × 2 - 7 × 3	Skin graft	45-180	2/5	100%	Cinpolat et al.
4th DMtAP	dorsal 5th toe defects	1	Small (~2 × 1)	Direct closure	180	None	100%	Van Alphen et al

Data analysis

The data from each selected article were compiled into two tables which amalgamated the anatomical characteristics of the flap and clinical use of the flap. Two reviewers were in charge of reading through the data available in each article and ensuring that the data were accurate and complete.

Results

Anatomical characteristics of the dorsal metatarsal artery flap

The dorsal metatarsal artery (DMtA) system of the foot is relatively reliable and is present from the 1st to 4th metatarsal spaces, as reported by a cadaveric study performed by Yeo et al.[4] The first DMtA flap has been most commonly performed in the literature, based on the main DMtA and not the perforator. The origin of the first DMtA comes from either the dorsalis pedis artery or the deep plantar artery which is also a branch of the posterior tibial artery. The DMtA runs along the dorsum of the foot and anastomoses with the plantar arterial system of the foot.[5] The DMtA usually lies superficial to the interosseous muscle but can also take an intramuscular course. Most of the DMtA perforators arise just distal to the juncturae of the extensor tendons. A constant perforator has been always reported to lie between the heads of each metatarsal, which is similar to the hand. The number of perforators given off by each DMtA ranged between 2-5 cutaneous perforators. The largest of all perforators was usually seen in the distal half of the DMtA, closer to the metatarsal heads. Methylene blue injection studies in cadavers showed an axial pattern of perfusion from these DMtAPs, measuring an average skin paddle size of 2.16 $\times$ 4.76cm in a longitudinal fashion[6] (Table 1).

Versatility and application of the DMtAP flap

Various DMtAP flaps of various perforators ranging from the 1st to 4th DMtAP have been reported. Its initial description was by Bharathwaj and Quaba in 1997 where they used the 1st DMtAP for resurfacing of dorsal forefoot defects following burns contracture release. The resulting donor defect was closed with a split thickness skin graft. Cinpolat et al[7] also used the 1st and 3rd DMtAP flap for post-traumatic defects, with a 90° rotation arc to cover defects over the 1st and 5th metatarsalphalangeal joint as well as the dorsum of the 4th toe. The authors harvested a larger flap measuring 8 cm in length by 1-4 cm, which resulted in them needing a skin graft for donor site coverage. Hallock et al[8] described the use of the 1st DMtAP flap for coverage of medial, lateral, and plantar aspects of the great toe. Yeo et al[4] reported a 2nd DMtAP flap for reconstruction of a 1st webspace defect with inset of the flap within the webspace which was maintained. Van Alphen et al[6] described the use of a 4th DMtAP flap for reconstruction of a dorsal 5th toe defect (Table 2).

Our surgical technique

A patient presented with a 1.5 mm Breslow thickness superficial spreading melanoma excised between the dorsum of the 2nd and 3rd toes on his right foot. A 2 cm wider local excision and sentinel lymph node biopsy was offered to the patient as part of his melanoma treatment. The resulting defect would involve both the web spaces between the 2nd and 3rd toe as well as the dorsum of the foot, resulting in exposure of extensor tendons and violation of the webspace. Various options of reconstruction ranging from local to free flap options were offered, including artificial dermal matrices. The patient opted for a local flap reconstruction in which a 3rd DMtAP flap was performed.

An 8 MHz Doppler was used to locate a perforator in between the 2nd and 3rd metatarsal heads. Under tourniquet control, an exploratory incision was made on the tibial border of the drawn flap. The flap is elevated in a subfascial fashion proximal to distal with sharp dissection. Small perforators are cauterized, and care is taken when the distal portion of the flap is reached between the heads of the metatarsals. The perforator was identified which matches with the preoperative Doppler site. Confirmation with an intraoperative Doppler is performed before the rest of the flap is fully dissected. Dissection around the pedicle is done just enough to release the flap to allow rotation. When comfortable, the flap is inset, and the donor site is closed. There were no postoperative complications encountered, and the patient was mobilized and discharged after 3 days with a splint to avoid toe flexion (Figs. 1 and 2).

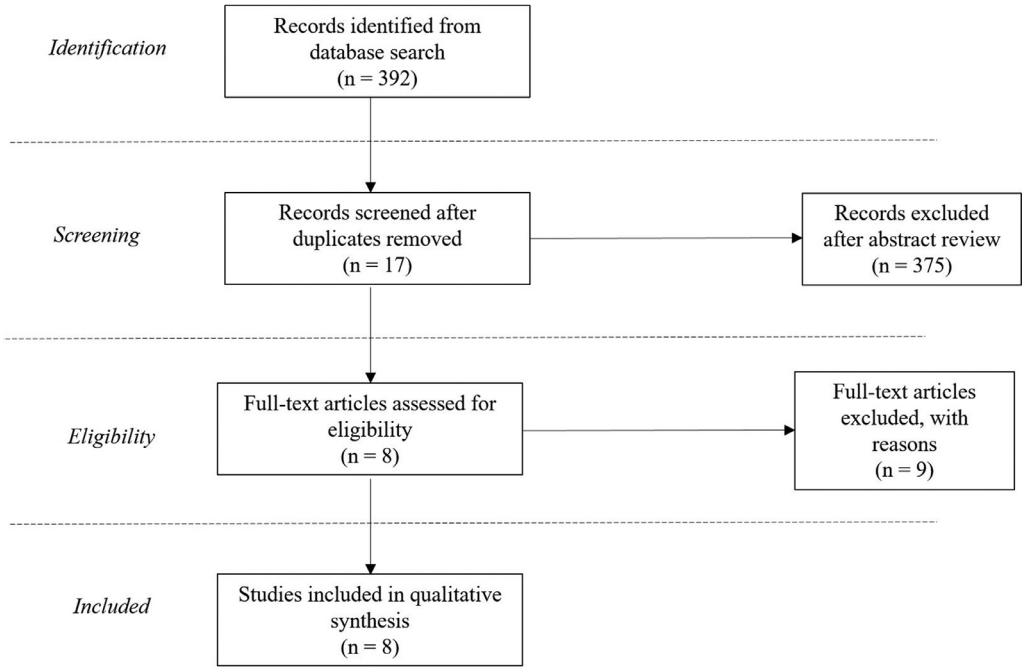

Fig. 1. Study selection process flowchart (from the preferred reporting items for systematic reviews and meta-analysis (PRISMA) statement).

Fig. 2. Photographs demonstrating the raising and final appearance of the DMtAP flap. (a) Photograph of the flap raised and the distal defect with exposure of tendons and webspace (blue dye for sentinel lymph node biopsy). (b) Inset of the DMtAP flap into the defect. (c) Final closure and insertion of drains. (d) 3-month lateral view of the flap and donor site (e) End on view of the DMtAP flap.

Discussion

The DMtAP flap allows for soft tissue reconstruction without the need for dissecting out the main pedicle or DMtA pedicle. This reduces the amount of donor site morbidity and surgical time without the need for intramuscular dissection within the interossei muscles. Our increased understanding of the anatomy and application of 1st – 4th DMtAP flaps should increase the usage of this perforator flap in our armamentarium for reconstructing difficult areas of the forefoot. Local options when working up the reconstructive ladder should always be considered as they are relatively simpler when executed well. The techniques used for raising any perforator flap can be applied to this flap, and ideally, if possible, the donor site should be closed directly. This limits the size of the flap to roughly 2 × 4cm depending on the location of the DMtAP. Venous congestion may be encountered, and application of leeches or releasing tension on the wound edges may help. Excessive flexion of the toes may put undue pressure and tension on the pedicle which will result in vascular compromise of the flap. A supporting backslab can be placed to keep the ankle dorsiflexed postoperatively to allow stabilization of blood flow to the flap. If executed well, webspace reconstruction and coverage of extensor tendons can be done in one sitting as compared to other methods such as artificial dermal matrices or complex procedures like free tissue transfer.

Author Contributions statement

All authors contributed extensively to the work presented in this paper. WK, CYYL, and NE conceived the study. WK, CYYL, and VG wrote and edited the main manuscript. WK, CYYL, and NE designed the experiments. WK, CYYL, and VG performed the experiments and analyzed the data**.**

Declaration of Competing Interest

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

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