

# Quantifying the Amount of Blood Flow Needed to Heal a Transmetatarsal Amputation

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## Introduction

A subset of patients with peripheral vascular disease (PVD) can develop critical limb ischemia that may lead to the need for performing a transmetatarsal amputation (TMA). Currently, there is no gold standard diagnostic criteria to determine the viability of a TMA.

In a recent study, the TransAtlantic Inter-Society Consensus (TASC II) infrapopliteal classification was used to measure infrapopliteal disease and its associations with higher amputations, major adverse limb event rates, and primary patency rates up to a year after vascular intervention. The results showed that more severely stenosed (C/D lesions), smaller target vessel diameter and chronic total occlusions had higher amputation rates and major adverse limb events than the A/B (mildly stenosed) infrapopliteal lesions <sup>1</sup>. This study showed a correlation between severity of vessel stenosis and likelihood of amputation, but did not specifically address transmetatarsal amputations. Other studies have compared changes in TMA survival based on microcirculation <sup>2</sup>. However, most institutions do not have these tools available to use to measure the viability of a TMA.

To date, there are no research studies quantifying the amount of blood flow needed to heal a TMA. This retrospective study evaluates all patients from 2013-2016 that have undergone a TMA with an angiogram, and measures if there is a correlation between quantity of blood flow (number of vessels patent to the foot and their respective vessel diameters) and a successful TMA.



Figure 1.

Angiogram after angioplasty(left).

Post-operative TMA with necrosis and dehiscence which eventually went on to a BKA (right).



Figure 2.

Patient showing two vessel flow on an angiogram after angioplasty (left).  
Post-operative TMA site which eventually heals successfully (right).

## Methods

This retrospective study investigated all patients from 2013-2016 from GSAA Kaiser and Kaiser Santa Clara who underwent a TMA within 3 months of a pre or post-operative angiogram (with or without an angioplasty/stenting procedure). N= 22 patients were found to qualify. The primary outcome measured was whether subjects healed or went on to wound dehiscence within 3-months of the TMA. Secondary outcomes included measurements of vessel patency involving the posterior tibial artery, anterior tibial artery, and perforating peroneal artery. Measurements were recorded as single, dual or 3-vessel perfusion to the foot, and vessel diameter as <1mm, 1-2mm, 2.1-3mm categories.

Measurements were obtained by reviewing diagnostic/therapeutic angiograms. The number of patent vessels as well as their respective diameters at the level of the ankle were measured using the institution's electronic imaging software PACS.

The measurements were obtained by two blinded investigators, and reviewed by a vascular surgeon. Data extraction and statistical analysis were performed and a Pearson correlation coefficient calculated per each subgroup analyzed.

## Results

9 of the 22 patients who underwent a TMA and angiogram/angioplasty went on to successful healing of the surgical site. There is a positive correlation ( $p < 0.05$ ) between number of vessels patent to the foot and the viability of a TMA. Subjects with 2 or 3 patent vessels had a greater likelihood of healing (8/22), whereas those with single vessel perfusion had a low likelihood of healing (1/22). 1/8 of those with single vessel perfusion healed, whereas 8/13 of those with dual or three vessel perfusion healed as shown in figure 3. There is no correlation between vessel diameter size and healing rates. Overall, the anterior tibial artery is most often patent (15/22, 68%). Subjects with at least dual or three vessel perfusion correlate with a larger diameter of the anterior tibial artery and posterior tibial artery ( $p < 0.05$ ).

Other subgroup analysis findings showed that most patients (20/22) have had at least one prior history of amputation, whether digital or partial ray amputations, prior to receiving a TMA. Many of our patients also had a previous history of smoking (10/22), and the patients studied were mostly male (17/22) with bimodal distribution of ages 56-65 (7/22) and 76-85 (7/22) years old.

## Discussion

TMA's are one of the most common limb salvage procedures. Many of these patients have PVD and undergo some form of endovascular procedure. Based on the analysis of our data, we found a positive correlation between the ability to heal a TMA and the number of vessels patent to the foot. 2 or more vessels perfusing the foot increased the likelihood of a successful TMA, as expected, since this implies there is greater vascular perfusion to the site. However, there is no association between the type of artery patent and the ability to heal. Contrary to popular anecdotal belief, the results of this study do not attribute greater success of healing to a patent posterior tibial artery.

Larger vessel diameter size of the PT/AT/perforating peroneal arteries also do not correlate with greater success. Our hypothesis proved to be false in that increased diameter size did not correlate to greater healing of a TMA. Based on our results, one should place more emphasis on the number of vessel perfusion to the foot rather than on the diameter of the vessel itself.

		Failed	Healed	Total = 22
0	No vessel perfusion	1 (100%)	0 (0%)	1
1	Single perfusion	7 (87.5%)	1 (12.5%)	8
2	Dual perfusion	5 (45.5%)	6 (54.5%)	11
3	Three vessel perfusion	0 (0%)	2 (100%)	2

Figure 3. Table of vessel perfusion and correlation to healing

## Conclusion

When evaluating a patient with PVD and his/her ability to heal a TMA, our study suggests that if there is more than one vessel patent to the foot, regardless of which ones they are (PT/AT/perforating peroneal), there is an increased likelihood of healing the surgical site. Contrary to popular anecdotal belief, our study does not attribute greater success with a patent posterior tibial artery. We must acknowledge that our study is limited in its implications due to its small sample size (n=22), and that an increased number of subjects would be needed prior to drawing any conclusions which may change clinical practice. Further studies on this subject may help clinicians counsel patients on whether they are candidates for a TMA based on the quantity of vascular perfusion. This may influence clinicians to recommend a primary BKA rather than attempt a procedure with a low likelihood of success.

## References

- 1) Singh, Gagan D., et al. "Midterm Outcomes After Infrapopliteal Interventions in Patients With Critical Limb Ischemia Based on the TASC II Classification of Below-the-Knee Arteries." *Journal of Endovascular Therapy*, vol. 24, no. 3, 2017, pp. 321-330., doi: 10.1177/1526602817704643.
- 2) Kawarada, O., et al. "Effect of Single Tibial Artery Revascularization on Microcirculation in the Setting of Critical Limb Ischemia." *Circulation: Cardiovascular Interventions*, vol. 7, no. 5, 2014, pp. 684-691., doi:10.1161/circinterventions.113.001311.

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