



# The Angiosome Concept vs. Pedal Arch Patency

Is this a new gold standard  
in the treatment of ischemic foot wounds?

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## Introduction

The prevalence of critical limb ischemia (CLI), the most advanced and thus severe form of peripheral arterial disease (PAD), has continued to rise as it is often under-treated and under-diagnosed, affecting roughly 12% of the adult population in the United States.<sup>1-5</sup> Consequently, between one and three million Americans are at risk of the significant morbidity and mortality associated with CLI. After only one year of being diagnosed with CLI, there is a 25% chance that the patient will die and a 30% chance of limb amputation.<sup>2,5,6</sup> Five years after diagnosis, mortality rates increase dramatically to over 60%.<sup>2</sup>

Due to the devastating effects of CLI, the need for both immediate identification and effective treatment is quite evident. Accordingly, multiple treatment strategies and modalities have been employed, with perhaps the most popular strategy being angiosome-guided revascularization. In recent years, however, the validity and efficacy of angiosome-guided revascularization have become more controversial, prompting a search for vascular targets that could be more accurate predictors of wound healing and more effective in the revascularization of those with CLI.

In what follows, we will explore viewpoints on the importance of the angiosome concept and pedal arch patency in the revascularization of ischemic wounds and give our recommendations as to the direction in which the field of wound care should

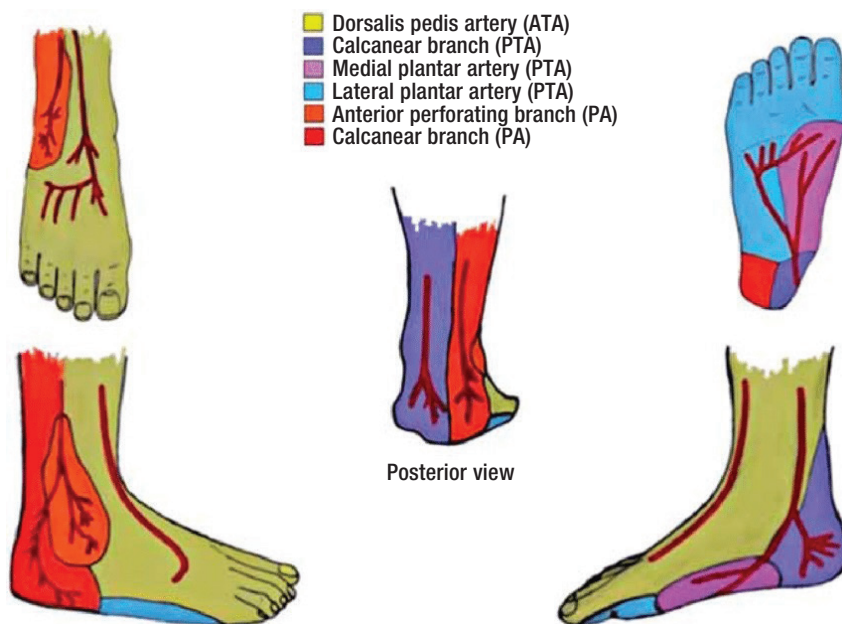


Figure 1: Angiosomes of the Foot and Ankle and Their Source Arteries (PTA: Posterior Tibial Artery; ATA: Anterior Tibial Artery; PA: Peroneal Artery). Setacci C, De Donato G, Setacci F, Chisci E. Ischemic foot: definition, etiology and angiosome concept. *The Journal of Cardiovascular Surgery*. 2010;51(2):223-231.

move in order to ensure more positive treatment outcomes for those with CLI.

## The Angiosome Concept

In 1987, Taylor and Palmer first introduced the angiosome concept into the field of reconstructive surgery for the purpose of planning flap placement.<sup>7</sup> The concept delineates the body as three-dimensional “blocks” of tissue supplied by a specific artery.<sup>8</sup> Each of these tissue blocks is connected to adjacent angiosomes by collateral vasculature, known as “choke

vessels”, providing redundant blood supply to the foot and ankle.<sup>9</sup>

There are six angiosomes in the lower extremity and three major source arteries. These arteries are: the posterior tibial artery, the anterior tibial artery, and the peroneal artery. The posterior tibial artery supplies three angiosomes: the medial calcaneal angiosome, medial plantar angiosome, and lateral plantar angiosome. The anterior tibial artery supplies one angiosome: the anterior tibial/dorsalis pedis angiosome. The

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peroneal artery supplies two angiosomes: the lateral calcaneal angiosome and the anterior perforating angiosome (Figure 1).<sup>10</sup>

Since its introduction, the angiosome concept has been of utmost importance in the revascularization of patients with CLI and has been regarded as the most effective way, intraoperatively, to restore and sustain adequate blood flow to an area of tissue ischemia.<sup>11</sup> Much of the literature seems to suggest that, regardless of the revascularization procedure being endovascular or bypass, direct revascularization (DR) of an angiosome has more favorable results concerning wound healing when compared to indirect revascularization (IR).<sup>12,13</sup> Some regard the use of the angiosome concept as an important factor in pre-operative planning when deciding the correct revascularization technique to be utilized.<sup>10</sup> Others even go as far as to say that surgeons should always consider the angiosome concept in order to preserve blood supply to an area of tissue ischemia.<sup>14</sup>

There are those, however, who question the validity of angio-

healing, adverse events, and amputation prevention.<sup>22</sup> Alternatively, Bekeny, et al. looked at patients with lower extremity wounds and found that although DR is the current gold standard, revascularization using indirect revascularization via collaterals (IR-C) may give superior healing results, especially in patients with high comorbidities, and can thusly serve as an adequate alternative when DR is not possible.<sup>23</sup> Research has also shown that angiosomes change depending on PAD severity.<sup>14</sup> This, coupled with the reality that some wounds have dual supply from multiple angiosomes, makes angiosome designation subjective at times.<sup>11</sup>

Besides inconsistency with definitions and anatomical differences among patients, some argue that other factors exist that are simply more important predictors of wound healing and successful outcomes. Through the evaluation of 249 limbs that underwent bypass surgery for PAD, Azuma, et al. suggested that factors such as location, severity of the wound, and comorbidities such as diabetes, end-

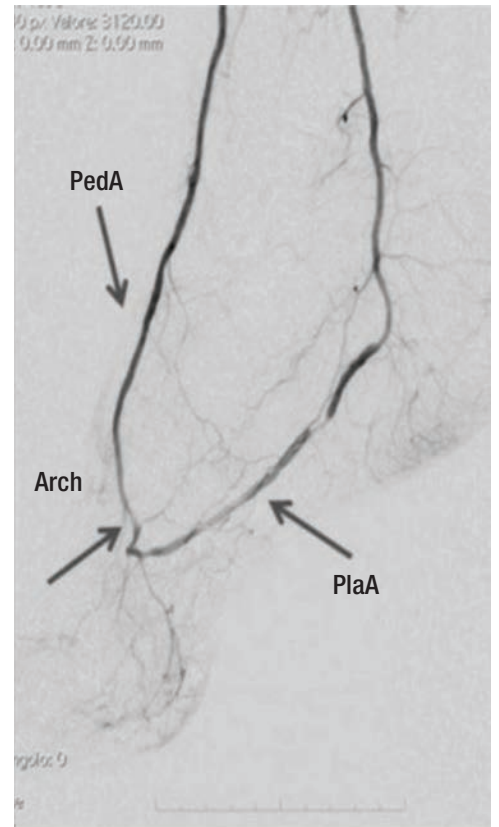


Figure 2

While there are important similarities between the angiosome concept and the pedal arch approach, the evidence to support the role of the pedal arch in wound healing seems to be even more promising compared to that of the angiosome concept (Figure 3).

A retrospective study by Jung et al. looked at a cohort of 239 patients, 141 of whom underwent pedal artery revascularization (PAR), and found that successful PAR significantly improved wound healing in patients with CLI; thus, efforts should be made to revascularize the pedal arch whenever possible, especially when the pedal arch is completely absent.<sup>16</sup>

Settembre, et al. looked at 580 patients with CLI tissue damage who underwent endovascular (n=407) and surgical (n=173) revascularization of the infrapopliteal arteries and achieved a survival rate of 65.1% and leg salvage of 76.1% at two years post-operatively. After their analysis, they concluded that a patent pedal arch had significant impact on leg salvage and survival.<sup>26</sup>

Troisi, et al. looked at 93 diabetic patients who had undergone endo-

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## The pedal arch serves as a bridge between the anterior and posterior components of pedal circulation, making it an important area of blood supply in the foot.

some-guided revascularization. One of the main issues brought up against the angiosome concept and associated research is definitional inconsistency between publications. Different definitions of the foot angiosomes, DR, and IR exist, influencing the results of their respective studies.<sup>15-17</sup> This undoubtedly contributes to the varying opinions that exist on the matter, making it difficult to discern to what extent angiosome-guided revascularization is truly effective. Some may find significant benefit for DR over IR, but others have found inconclusive support.<sup>18-21</sup>

Chuter, et al. came to the conclusion that there is inconclusive evidence in the literature supporting the effectiveness of DR vs. IR for wound

stage renal disease (ESRD), and low-albuminemia may be more relevant in the healing of wounds post-bypass surgery compared to the angiosome concept alone.<sup>24</sup>

### The Pedal Arch

The pedal arch is formed by the deep plantar branch of the dorsalis pedis and a plantar artery, usually the lateral plantar artery (Figure 2);<sup>25</sup> therefore, the pedal arch serves as a bridge between the anterior and posterior components of pedal circulation, making it an important area of blood supply in the foot. In recent years, pedal arch patency has been explored as a new and appealing approach to ischemic wound revascularization and healing.



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vascular revascularization of at least one below-the-knee vessel, divided into three groups according to pedal status, and found that pedal arch patency and not direct angiosome revas-

of healing and time to healing.<sup>28</sup>

Kawarada, et al. also concluded that, after successful infrapopliteal intervention, patency of the pedal arch was shown to be a better predictor of wound healing compared to direct angiosome revascularization.<sup>29</sup>

impaired pedal arch patency adversely affects the collateral vasculature between angiosomes.<sup>31</sup> This could explain why much of the recent literature seems to support the notion that pedal arch patency is a better predictor of wound healing compared to direct angiosome revascularization.

**Currently, the gold standard of pedal arch evaluation is angiography; because of its price and potential complications, however, other forms of evaluation such as duplex ultrasound and Doppler ultrasound have been utilized.**

## Evaluating the Pedal Arch

Due to the progressive nature of CLI, accurate and quick diagnosis is paramount in the prevention of life-threatening complications. The standard vascular examination includes inspection, auscultation, and the evaluation of pulses either by palpation or by a handheld Doppler.<sup>6</sup> To ensure that the pedal arch can accurately predict positive wound healing outcomes in these patients with CLI as described above, one must be able to properly evaluate its patency. Currently, the gold standard of pedal arch evaluation is angiography; because of its price and potential complications, however, other forms of evaluation such as duplex ultrasound and Doppler ultrasound have been utilized.<sup>32,33</sup>

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cularization was a better predictor of limb salvage and wound healing after endovascular intervention.<sup>27</sup> Rashid, et al. evaluated the effect of pedal arch quality on patency rates of distal bypass grafts, and the direct impact on healing in 154 patients with CLI, and found that pedal arch patency rather than the angiosome revascularized was shown to directly affect rate

In a retrospective study of 120 patients with a history of CLI and tissue loss who received a peroneal artery bypass, Ricco, et al. concluded that patency of both peroneal branches and the pedal arch was more closely related to better healing and amputation prevention irrespective of the wound angiosome location.<sup>30</sup>

Finally, Shao, et al. concluded that

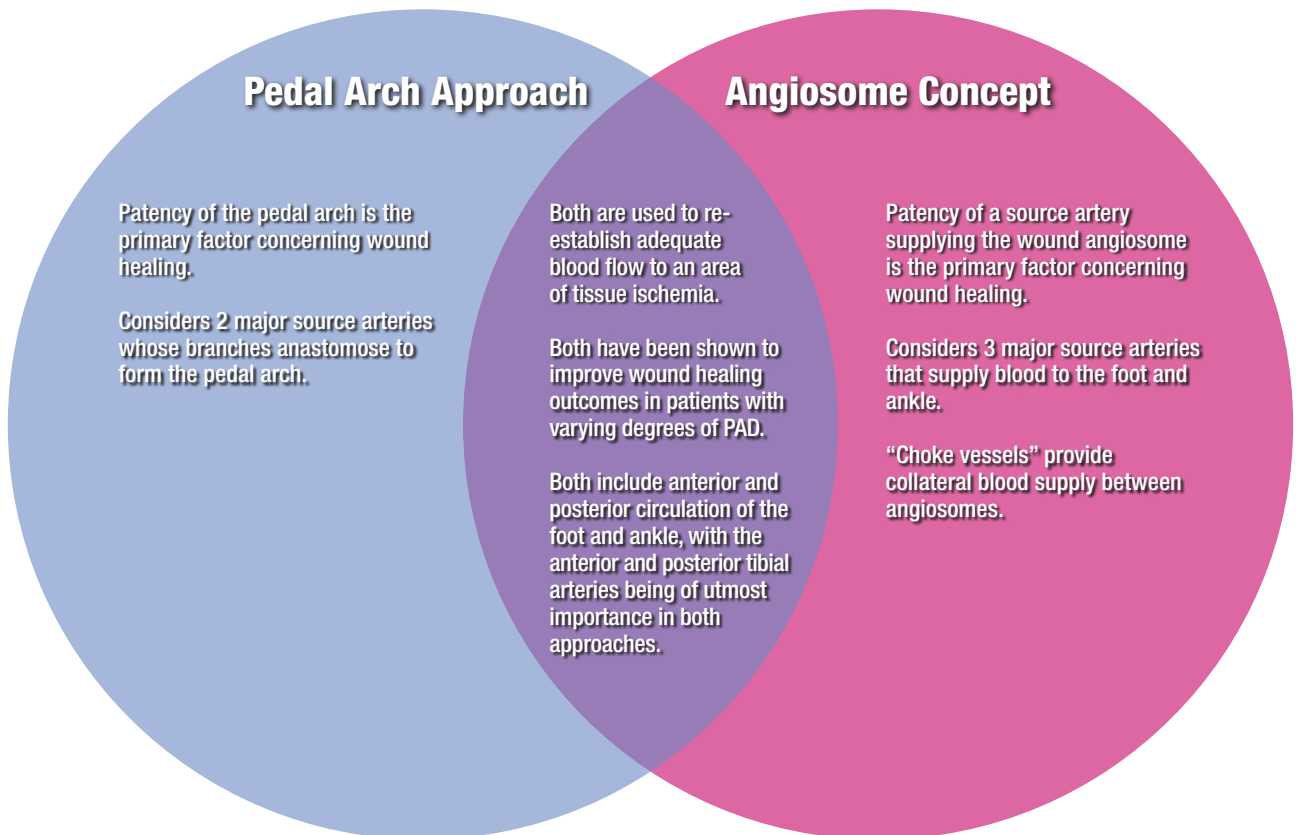


Figure 3: Similarities and Differences Between the Pedal Arch Approach and Angiosome Concept

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*Angiosome Concept (from page 61)*

Some commonly used Doppler-based studies include the ankle-brachial index and segmental pressure measurements; however, the presence of calcification resulting in non-compressible vessels, a problem very common to those with pedal arch disease, can negatively affect the accuracy of both ABI and segmental pressure measurements.<sup>3,34,35</sup> To circumvent this issue, some practitioners are using pedal acceleration time (PAT), a non-invasive, direct duplex imaging modality shown to be a more reliable assessment of pedal perfusion.<sup>36</sup> Teso, et al. showed

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**There seems to be too much contradictory evidence surrounding the angiosome concept at this time.**

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that PAT can be used to accurately assess patency and blood flow of pedal vessels in patients with non-compressible ankle pressures and/or non-obtainable toe pressures.<sup>37</sup> Furthermore, their study showed that a PAT of less than 180 milliseconds was associated with higher rates of limb salvage, regardless of whether direct blood flow to the wound bed was achieved.

### **Conclusion**

The new evidence in support of the pedal arch as a better predictor for wound healing in those with CLI, and thus a more appropriate target for revascularization compared to angiosome source arteries is exciting, especially considering the recent advancement of PAT contributing to a more accurate vascular assessment of these patients. It would, however, be a detriment to disregard the angiosome concept completely and claim that revascularization of the pedal arch is the new gold standard in the treatment of ischemic foot wounds. There seems to be too much contradictory evidence surrounding the angiosome concept at this time.

As mentioned previously, this is undoubtedly due to the lack of standardized and consistent definitions concerning angiosome borders, direct revascularization, and indirect revascularization. There also needs to be a larger volume of randomized controlled trials performed on both pedal arch patency as it relates to wound healing and the angiosome concept. Once the creation of standardized definitions is achieved and more reliable forms of research are conducted, one can come to a more reliable conclusion—thereby helping to clear up any further confusion and contradiction that exists and allowing practitioners to make more informed clinical decisions in the treatment of those with CLI. **PM**

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