

## Statement of Purpose

The purpose of the study is to evaluate the effects of timing between endovascular intervention and minor lower extremity amputations (digital, partial-ray, transmetatarsal) and the effects it has on healing.

## Methodology & Procedures

### Study Design:

A retrospective cohort study was conducted using the electronic medical records of 310 patients who had undergone endovascular intervention within 90 days prior to a pedal amputation within the Kaiser Northern California system from 2008 to 2014.

### Inclusion Criteria:

Continuous post-operative follow up after amputation, with endovascular intervention within 90 days prior to pedal amputation.

### Exclusion Criteria:

Intervention  $\geq 90$  days prior to pedal amputation, inadequate follow up, or open revascularization.

### Primary Exposure:

Time interval between revascularization to amputation (<30 days vs  $\geq 30$  days)

### Primary Outcomes:

- Optimal healing was defined as healed surgical site with suture removal within 2-4 weeks postoperatively.
- Delayed healing was defined a surgical site dehiscence which ultimately went on to heal by secondary intention within 3 months with local wound care.
- Failure was defined as an amputation that required either revision surgery, unplanned return to the operating room, surgical bypass, or a more proximal amputation within 12 months from the index amputation.

### Statistical Analysis:

Chi-square test was used to compare categorical variables.

## Literature Review

Vascular reperfusion has a profound role in limb salvage, however, the optimal time for revascularization has yet to be defined.<sup>1-5</sup> Jacobs described a practice of simultaneous amputation, while other researchers have recommended amputation 2-4 days following revascularization.<sup>6-8</sup> The rationale for a latency period has been described to allow for soft tissue improvement and demarcation of all non-viable soft tissue while improving tissue oxygenation, granting visualization of optimal skin edges.<sup>9-15</sup>

No studies directly investigate the outcomes of time to amputation with endovascular intervention, however, studies have compared bypass revascularization timing and healing outcomes. Sheahan et al. demonstrated, utilizing 670 patients, that delaying bypass revascularization after amputation was directly correlated with a decrease in limb salvage rates at one year irrespective to the reason for delay.<sup>7</sup> The importance of pre revascularization was further exhibited in their study by an observed downtrend in the number of non-healing amputations over the course of the study as adherence to a protocol proclaiming early revascularization was embraced.

Defining the optimal time for endovascular intervention in the setting of ischemic pedal amputation is crucial due to the paradigmatic shift toward the use of endovascular procedures over open vascular bypass, and also the high incidence of restenosis observed in endovascular techniques.<sup>9,15-17</sup> Restenosis rates have been reported to be roughly 70% at 3 months, which can adversely affect a patient's wound healing.<sup>16</sup>

	Gender	Race/ Ethnicity	HTN	CAD	CVD	CHF	PVD	DM	ESRD	Albumin	HgA1c	Tobacco
Optimal vs Delayed	0.8949	0.2420	0.6811	0.0792	0.3753	0.4306	0.1457	0.5302	0.8098	0.3859	0.8163	0.6129
Failure vs Optimal/Delayed	<b>0.0090* Male</b>	0.3560	0.7081	0.2620	0.7044	0.3989	0.7968	<b>0.0076* +DM</b>	0.0654	0.3736	0.7872	0.1803

There were no significant findings for demographics and co-morbidities in the optimal or delayed healing groups. Men and patients with diabetes were found to have a significantly higher chance of failure and need for subsequent amputation.

## Table 1: Healing Status by Time, n (%)

Time between revascularization and amputation (n=310)	Healed (n=148)		Failure to Heal (n=162)
	Optimal (n=86)	Delayed (n=62)	
<30 days (n=191)	48	45	98
$\geq 30$ days (n=119)	38	17	64

There was no difference between failed and healed outcomes when comparing revascularization to amputation times, however there is a difference between the percentage of optimal and delayed outcomes when comparing amputation time.

## Figure 1: Kaplan Meier Curve

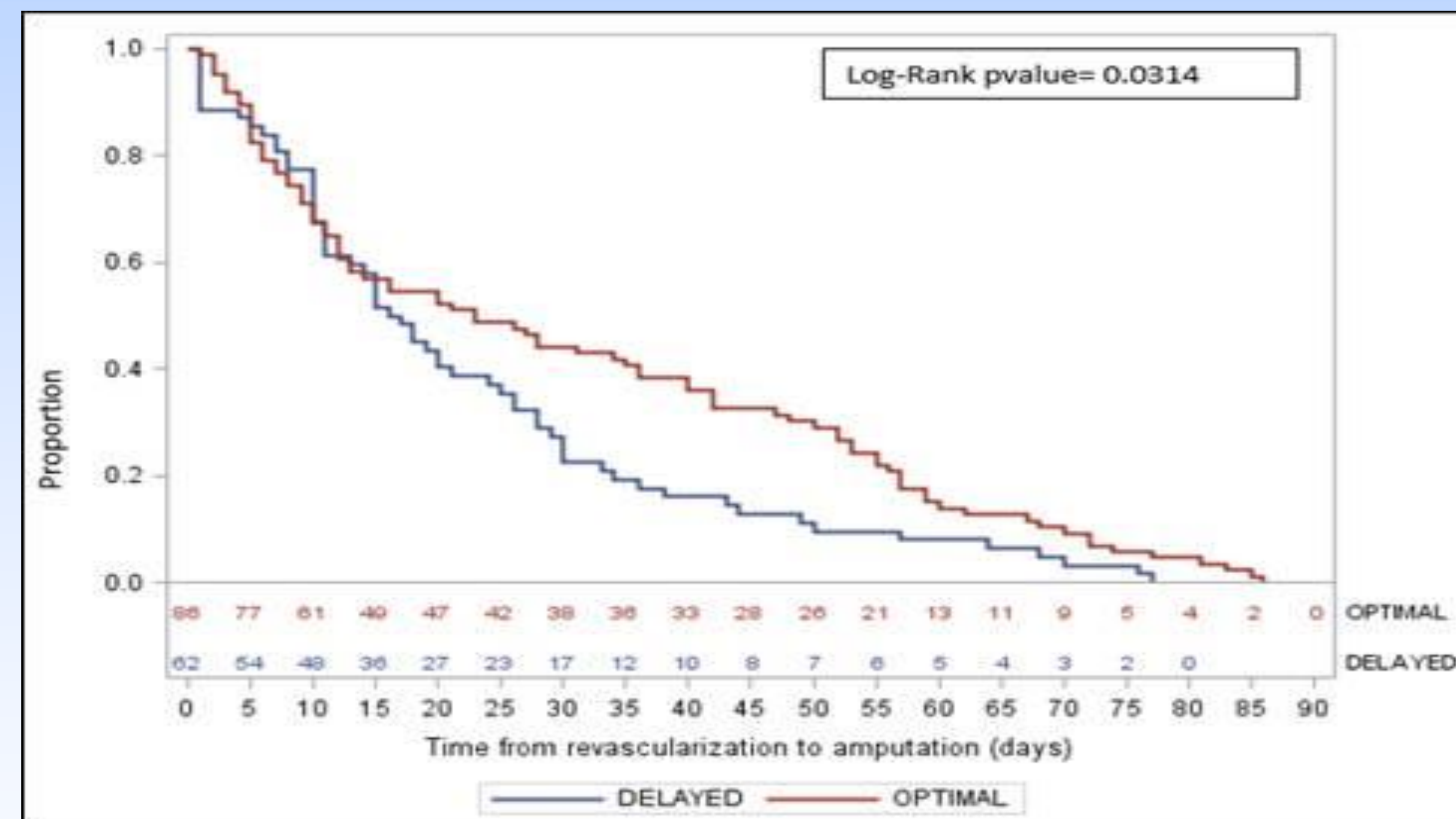


Table 2: Demographic and co-morbidity statistical values (p) comparing outcomes

## Results

- Out of the 310 patients who had undergone amputation following endovascular intervention, 86 patients healed optimally, 62 were delayed, and 162 failed. (Table 1)
- Time to revascularization after an amputation did significantly impact healing time when differentiating between optimal and delayed (**p=0.0373**). Performing pedal amputations within 30 days of endovascular intervention correlated with an increased propensity toward optimal healing.
- Figure 1 shows Kaplan Meier curves demonstrating time from revascularization to amputation, comparing group with optimal and delayed healing. The curve shows a significantly higher proportion with optimal healing specifically between 15 and 60 days of amputation after revascularization (**p=0.0314**).
- There was no significant difference in healing outcomes and time from revascularization to amputation when comparing a failed outcome to a healed outcome (optimal or delayed; **p= 0.6717**).
- Patient demographics/co-morbidities showed no significant differences on healing outcomes in optimal vs delayed.
- However, when analyzing failed versus healed (optimal or delayed) male gender and a history of diabetes significantly correlated with failure to heal. (Table 2)

## Analysis & Discussion

Open vascular bypass has long been the standard of care, although the use of endovascular procedures is increasing. The BASIL study concluded that both interventional strategies were associated with similar midterm outcomes in terms of amputation-free survival for patients with infrainguinal disease.<sup>18</sup> However, studies have observed that with this increasing trend in endovascular lower extremity interventions, there has been a concomitant drop in lower extremity amputation rates further, driving endovascular intervention over open bypass.<sup>19-20</sup>

Our results suggest that high restenosis rates may affect the healing outcomes following endovascular techniques as revascularization within 30 days of amputation performed better than revascularization  $\geq 31$  days. Previous studies have shown almost 2/3 of individuals develop restenosis 3 months following endovascular treatment.<sup>15</sup>

Timing of amputation after endovascular intervention is crucial given the rapid nature and high incidence of restenosis. Exploiting the maximal healing potential provided by endovascular intervention advances limb salvage by preventing non-healing pedal amputations from progressing to major lower extremity amputations. Based on our findings, amputation within 30 days after endovascular intervention may provide the best potential for optimal healing.

## References

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