Immediate changes of angiosome perfusion during tibial angioplasty

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ABSTRACT

Objective: In recent years, a controversial discussion about the clinical relevance of the angiosome concept during tibial angioplasty has developed. Therefore, we conducted a prospective study to evaluate the angiosome concept on the level of microcirculation during tibial vascular interventions.

Methods: Thirty patients with isolated tibial angioplasty were examined prospectively. Macrocirculation was evaluated by measurement of the ankle-brachial index (ABI). For the assessment of microcirculation, a combined method of laser Doppler flowmetry and tissue spectrometry (O2C; LEA Medizintechnik GmbH, Giessen, Germany) was applied. Microcirculatory parameters were measured continuously during the procedures. Measuring points were located over different angiosomes of the index foot; a control probe was placed on the contralateral leg.

Results: Cumulated microcirculation parameters (sO_2, flow) as well as the ABI showed a significant improvement postinterventionally (ABI, $P < .001$; sO_2, $P < .001$; flow, $P < .001$). Assessment of the separate angiosomes of the index leg and the comparison of the directly revascularized (DR) and indirectly revascularized (IR) angiosomes showed no significant difference concerning the microperfusion postinterventionally (DR − IR: sO_2, $P = .399$; flow, $P = .909$) as well as during angioplasty. Even a further subdivision of the collective into patients with diabetes (sO_2, $P = .445$; flow, $P = .758$) and renal insufficiency (sO_2, $P = .246$; flow, $P = .691$) could not demonstrate a superiority of the direct revascularization at the level of microcirculation in these patients (comparison DR − IR).

Conclusions: There is a significant overall improvement in tissue perfusion of the foot immediately after tibial angioplasty. The effect shown in this study, however, was found to be global and was not restricted to certain borders, such as defined by angiosomes. (J Vasc Surg 2017;65:422-30.)

In recent years, a controversial discussion concerning the most important factors for sufficient wound healing in the critically ischemic limb has developed. By now, it is largely agreed that restoring a pulsatile flow to the ischemic foot seems to be the crucial point in revascularization.[1] Furthermore, studies showed an improvement of the microperfusion after revascularization; this has been recognized as an essential factor in terms of wound healing.[2]

In this context, the concept of an angiosome-targeted revascularization has increasingly gained attraction. The angiosome concept was initially described by Taylor and Palmer in 1987.[3] They described 40 angiosomes of the human body and divided the body into three-dimensional vascular territories supplied by specific source arteries and drained by specific veins. They defined five distinct angiosomes of the lower legs as fed by the medial sural artery, lateral sural artery, posterior tibial artery (PTA), anterior tibial artery (ATA), and peroneal artery (PA). The concept was immediately widely accepted and applied in plastic and reconstructive surgery with use in pedicled and free tissue transfer.[4] In 2006, Attinger et al[5] transferred the concept to the foot and defined six angiosomes arising from the PTA, ATA, and PA, which gained importance in revascularization of patients with critical limb ischemia (CLI). They distinguished direct revascularization (restoring direct blood supply to an angiosome containing an ulcer) from indirect revascularization (restoring blood supply to a neighbor angiosome, not containing an ulcer). To evaluate this concept, a number of retrospective analyses including two meta-analyses have been conducted.[1,6-16] However, a review article by Sumpio et al[17] concerning the question of superiority of direct revascularization showed that the overall results turned out to be heterogeneous. The majority of recently published studies evaluate the concept retrospectively regarding the end point of wound healing as well as amputation-free survival, which are end points affected by a variety of factors besides direct and indirect revascularization.

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To gain further information about the possible changes taking place in the different angiosomes during revascularization, we measured the microperfusion during tibial endovascular intervention by means of light-guided Doppler flowmetry. We assessed the microcirculatory parameters continuously during tibial balloon angioplasty in the different angiosomes of the foot.

The aim of this study was to obtain further information on microcirculation changes during tibial revascularization. Furthermore, we tried to validate and evaluate the relevance of the angiosome concept by means of microcirculation measurements during tibial intervention.

METHODS

Patients. A prospective analysis of 30 consecutive patients presenting with CLI was performed (19 men, 11 women). The study cohort consisted of patients with Rutherford stage 4 to 6 only. The data were prospectively collected between January and December 2015. The study was conducted in congruence with the Declaration of Helsinki and was approved by the local ethics committee; informed consent was obtained by all patients.

Study design. Preinterventional magnetic resonance angiography was performed if no contraindication was present. In cases of contraindication to magnetic resonance imaging, such as pacemaker or claustrophobia, primary diagnostic digital subtraction angiography was conducted. Only patients with isolated infrageniculate involvement requiring endovascular therapy at Rutherford stages 4 to 6 were included. To classify the tibial lesions and to assess the calcification severity, the TransAtlantic Inter-Society Consensus (TASC) classification was used (Table I).[18] To classify the intrapedal circulation of the foot, we graded the foot angiograms into four categories as proposed by Kawarada et al (Table I).[19] Category I was defined as complete pedal arch, with patent dorsalis pedis and plantar artery. Category IIa was graded in case of patent dorsalis pedis artery and occluded plantar artery; category IIb, in case of patent plantar artery and occluded dorsalis pedis artery. Category III was defined as collateral foot perfusion without patent pedal vessels. For grading of the angiograms according to the TASC and pedal arch classifications, the angiograms were reviewed by two independent radiologists.

For each patient, the macrocirculation as well as the microcirculation was investigated. To evaluate macrocirculation, the ankle-brachial index (ABI) was measured preinterventionally and postinterventionally. Patients with unreliable elevated ABIs were excluded from the calculation of the mean values. Because of previous minor amputations and toe gangrene in a considerable part of the included patients, the toe-brachial index was not feasible for evaluation of macroperfusion in our study cohort. Assessment of the microcirculation

Table I. Procedure characteristics and lesion characteristics

Treated tibial vessels	39
ATA	15
PTA	4
PA	20
Resulting patent tibial vessels	
1	17
2	13
Rutherford stage	
4	8
5-6	22
Tibial TASC classification of lesions	
TASC A	1
TASC B	17
TASC C	6
TASC D	6
Pedal arch classification	
I	3
IIa	9
IIb	6
III	12

ATA, Anterior tibial artery; *PA*, peroneal artery; *PTA*, posterior tibial artery; *TASC*, TransAtlantic Inter-Society Consensus.
Data are presented as numbers.

was made by the use of a combined method of laser Doppler flowmetry and tissue spectrometry (O2C, "oxygen to see"; LEA Medizintechnik GmbH, Giessen, Germany). The investigation of the microperfusion was conducted peri-interventionally in the angiography suite. Furthermore, three measuring points were allocated on the index leg according to the angiosome concept; a control probe was placed on the contralateral leg. During the whole endovascular procedure, the positioned probes measured continuously; certain markers were set by the investigator to mark the individual steps of the procedure.

Endovascular procedure. Infrapopliteal PTA procedures were performed under local anesthesia by transfemoral antegrade puncture using 5F sheaths; 5000 IU of unfractionated heparin were applied, and the lesions were probed with 0.018- or 0.014-inch coronary-type guidewires. Balloon diameters varied between 2 and 3 mm for tibial vessels and were 1.5 mm for pedal arteries. No stents were applied below the knee. Angiographic success was defined as a residual stenosis of $<30\%$, the absence of flow-limiting dissections, and at least one patent infrapopliteal artery for direct blood flow or in-line flow through the PA to the foot. Postinterventional management consisted of 2 days of activated partial thromboplastin time-controlled intravenous heparinization (target partial thromboplastin time, 60-80 seconds) and afterward dual antiplatelet medication with clopidogrel (75 mg) and aspirin (100 mg) during a 4-week period.

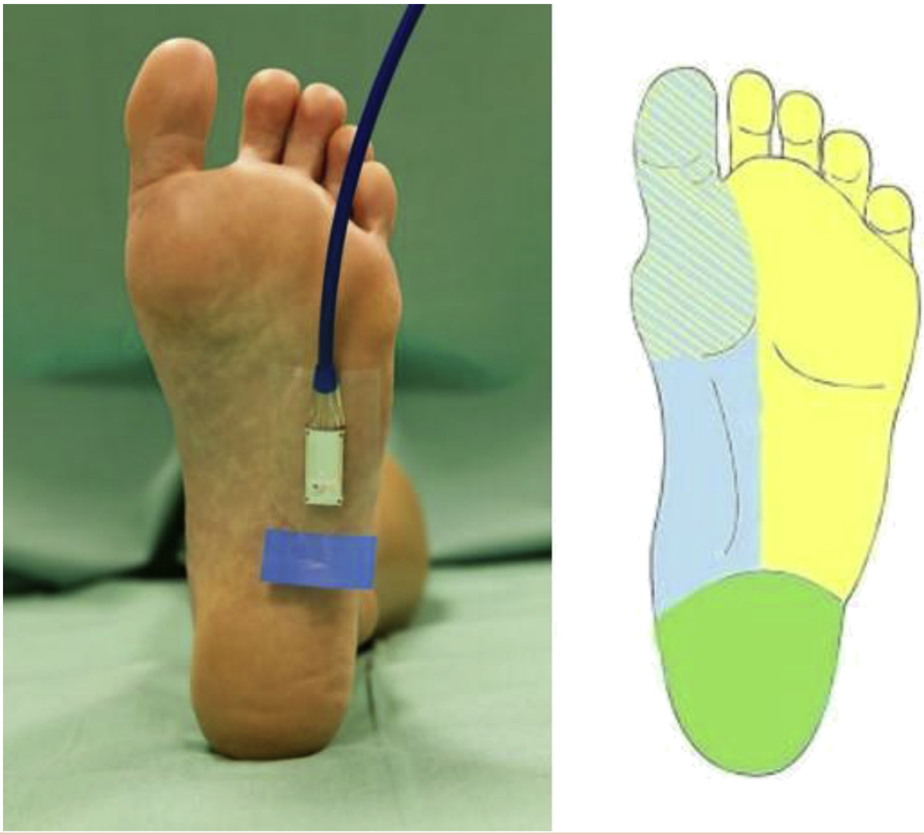

Fig 1. Probe placed in the angiosome of the posterior tibial artery (PTA) on the plantar foot.

Three probes were placed on the index foot, with one probe located in each foot angiosome. For our measurements, we adopted the definition of angiosomes and their borders on the foot as described by Attinger et al.[5] Areas not clearly attributable to a single angiosome because of known interindividual variability, such as the great toe and the heel, were not chosen for probe positioning. The probe positioning is presented in Figs 1-3. One control probe was located on the contralateral leg.

Measurements were conducted continuously during the whole intervention. For the postinterventional evaluation of the microcirculation parameters, three time points of interest were defined to further analyze the graphs: Pre, Post, and Int. The first time point (Pre) was calculated as a mean value of the first 60 seconds (Pre) after the antegrade sheath was positioned in the common femoral artery of the index leg. Accordingly, time point Post comprised the period of 60 seconds after removal of all catheters except the sheath; as for time point Pre, the mean was calculated for further analyses. To evaluate the microcirculation changes during the angioplasty procedure itself, another measuring point was introduced for the period when the angioplasty balloon was inflated; here, the mean was calculated over a time of 10 seconds directly before balloon deflation (Int).

Depending on the revascularized infrageniculate artery, the directly revascularized (DR) and indirectly revascularized (IR) angiosomes could be determined postinterventionally. When two tibial arteries were revascularized, the mean values of the microcirculation parameters (oxygen saturation [sO_2] of hemoglobin, flow) of both DR angiosomes were used for the calculation of the DR angiosome parameters.

Technical aspects O2C (oxygen to see). The O2C is a combined method of laser Doppler flowmetry and tissue spectrometry for measurement of tissue microperfusion by the following parameters: sO_2 (in percentage), relative hemoglobin amount (rHb, in arbitrary units [AU]), relative blood flow (AU), and blood flow velocity (AU).[20-24] It uses white light of 500- to 630-nm wavelength as well as laser light of 830-nm wavelength. A laser Doppler shift is caused by the movement of the erythrocytes, which is then detected by the device as blood velocity. The amount of erythrocytes, which is indirectly detected by the absorption of the hemoglobin in the detected volume, combined with the velocity value yields the overall flow. Emitted white light registers the hemoglobin sO_2 and rHb amount. The sO_2 is determined by the color of the blood. The absorption of the white light in the tissue gives an indication of the rHb parameter.

The rHb did not provide relevant information on the concern of CLI during continuous measurement. Velocity is enclosed in the parameter flow. Therefore,

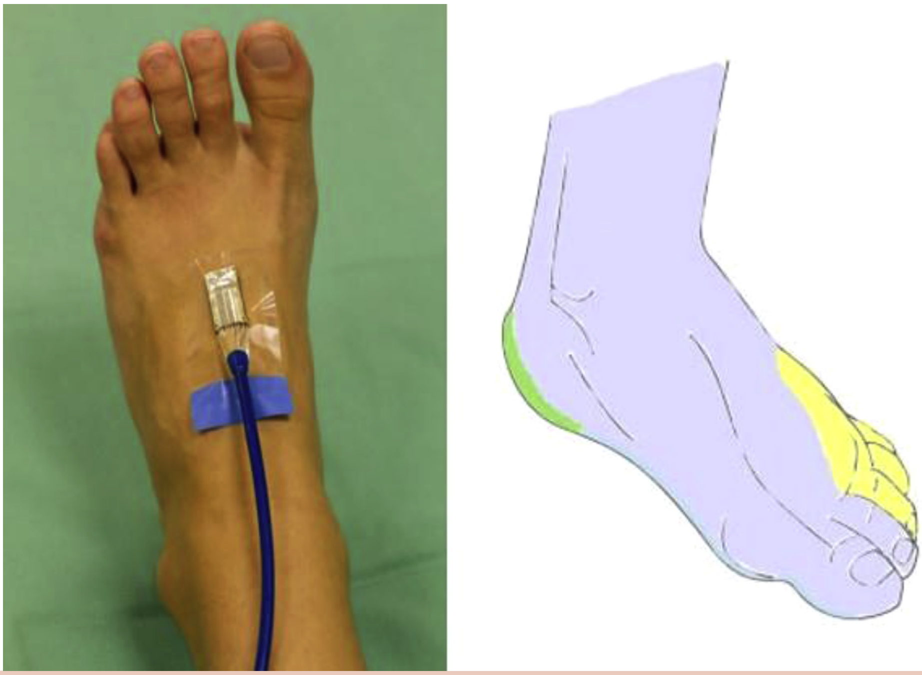

Fig 2. Probe placed in the angiosome of the anterior tibial artery (ATA) on the dorsum of the foot.

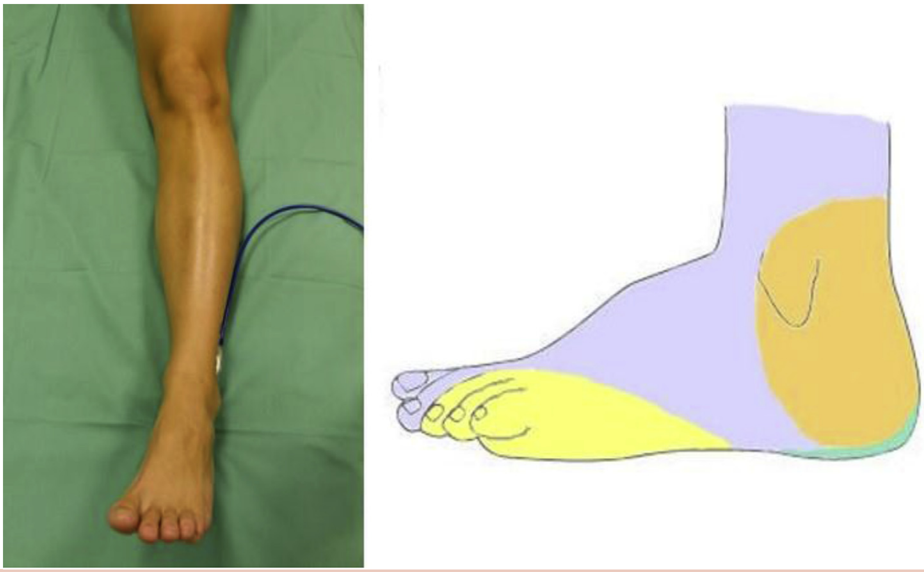

Fig 3. Probe placed in the angiosome of the peroneal artery (PA) on the lateral ankle.

the measurements were subsequently focused on the parameters sO_2 and flow.

The O2C is available for different types of probes. Depending on the emitted light wavelength as well as the distance between the illumination and the detection point (called separation), different tissue depths are being evaluated.[25] In this study, we made use of four probes of the LF-2 (Serial number LF-129) that offers a measuring range of 2- to 8-mm tissue depth and works with a wavelength of 500 to 850 nm. Because of its separation, the probes mainly work at a tissue depth of 3 mm. Similar probes have proven feasible for CLI patients in previous studies.[2,26]

Statistical analysis. SPSS 21 (IBM Corp, Armonk, NY) was used for the statistical analysis. Because of slightly skewed distributions of microcirculation parameters, nonparametric techniques were used for the analysis. Statistical analyses of differences between DR and IR angiosomes focused on comparing changes between preinterventional and postinterventional values in the outcome parameters were statistically realized by using the Wilcoxon signed rank test. Descriptive information about the central tendency and dispersion of the data is given by the median and the range, described by the highest and lowest value (except for age, for which the mean with minimum and maximum is provided). The statistical significance level was set to $P < .05$. One control probe was placed on the contralateral leg. Therefore, a continuous monitoring of the blood pressure situation was realized, which was not influenced by sheaths or catheters compared with the index leg. Concerning the microcirculation parameter flow, the changes of the control probe during the continuous measurement were used to adjust the values of the index probes for the blood pressure situation. Thus, the control probe served as a correction tool to avoid confounding of flow values by individual blood pressure undulation during the measurements. For the parameter sO_2, this was not valuable as more factors, such as oxygen exhaustion and the changing of the volume situation, are influencing this parameter.

RESULTS

Patients' comorbidities complied with the typical vascular risk profile (Table II). The mean age of the patients was 76.13 years (50-85 years).

Among the 30 prospectively assessed patients, technical success, defined as residual stenosis <30%, the absence of dissections, and the establishment of at least one infrapopliteal artery with direct flow or in-line flow through the PA to the foot, was achieved in all included patients. A total of 39 infrapopliteal vessels were treated (ATA, 15 times; PTA, 4 times; PA, 20 times). In 17 cases, the treatment resulted in one patent tibial vessel after intervention; in 13 cases, it showed two patent vessels. Additional patient and procedure characteristics are shown in Tables I and II.

A significant improvement of the postinterventional ABIs was obtained in all patients except for one case in which a nonsignificant improvement could be demonstrated. The mean preinterventional ABI was 0.50 (range, 0.31-1.11). After intervention, an improvement to a mean ABI of 0.94 (range, 0.50-1.14) was recognized (a total of 10 patients were excluded from the calculation because of unreliable elevated ABIs; $P < .001$).

Measurement of the microcirculation parameter was conducted continuously during intervention. The mean of the overall postinterventional sO_2 parameters of the index leg was 62.39% (range, 2.12%-98.04%) and showed a significant improvement ($P < .001$) compared with the preinterventional parameters, 45.73% (range, 1.00%-95.55%). Accordingly, the overall postinterventional flow parameter (32.01 AU; range, 0.34-224.87 AU) demonstrated a significant improvement compared with the preinterventional parameters as well (19.96 AU; range, 0.00-231.91 AU; $P < .001$).

Table II. Patient characteristics

Age, years (min-max)	76.13 (50-85)
Sex	
Male	19 (63)
Female	11 (37)
Comorbidities	
Diabetes	21 (70)
Renal insufficiency	18 (60)
Stage 2	3 (10)
Stage 3	11 (37)
Stage 4	3 (10)
Stage 5	1 (3)
Smoker (currently smoking)	4 (13)
Dyslipidemia	20 (67)
Hypertension	27 (90)

Data are presented as number (%) unless otherwise indicated.

To assess the influence of a one- and two-vessel outflow on the microcirculation of the foot, the difference of the improvement between the preinterventional and postinterventional microcirculation parameters was calculated. By comparing the median values of the differences between a one- and two-vessel outflow, no significance could be detected (sO_2, $P = .651$; flow, $P = .750$; Table III).

For the evaluation of the individual angiosome perfusion, the probes—each placed in a different angiosome (ATA, PTA, PA)—were assessed separately. By selective comparison of each angiosome, the preinterventional and postinterventional microcirculation parameters showed a significant improvement independent of the particularly treated tibial vessel (Table III).

For further differentiation, each angiosome was defined as directly or indirectly revascularized (DR and IR angiosomes), depending on the treated infrapopliteal vessel. Accordingly, evaluation of sO_2 and flow parameters showed a significant increase in both DR and IR angiosomes postinterventionally (Table IV). For a comparison of the DR and IR angiosomes, a calculation of the differences describing the relative improvement between preinterventional and postinterventional values was performed. The comparison of the mean differences showed no significant differences for both parameters as shown in Table V.

Further differentiation was made according to the patient's individual risk profile. The data were subdivided into diabetic (n = 21) and nondiabetic patients (n = 9). Comparison of the DR and IR angiosomes showed no significant differences in the diabetic as well as in the nondiabetic group. Similarly, data were split into renal insufficient (n = 18) and non-renal insufficient patients (n = 12). Even in this subgroup, the comparison of the DR and IR angiosomes showed no significant differences (Table V).

Table III. Comparison of the median of the preinterventional and postinterventional microcirculation parameters of each angiosome as well as the one- and two-vessel outflow of the lower leg

	Parameter	Preinterventional, median (range)	Postinterventional, median (range)	*P* value
PTA	sO_2	51.12 (12.21-79.46)	65.27 (8.88-86.93)	<.001
	Flow	22.41 (0.07-231.91)	36.85 (1.44-224.87)	.012
PA	sO_2	43.29 (1.00-95.99)	60.10 (3.79-98.04)	<.001
	Flow	14.81 (0.00-98.37)	20.67 (0.34-159.61)	.041
ATA	sO_2	45.06 (2.02-77.89)	61.30 (2.12-96.57)	<.001
	Flow	17.44 (0.12-66.71)	32.93 (0.81-157.68)	.009
One-vessel outflow	sO_2	45.74 (1.00-94.26)	62.79 (2.12-96.36)	<.001
	Flow	17.44 (0.00-231.91)	33.22 (0.34-224.87)	.002
Two-vessel outflow	sO_2	49.31 (32.81-95.99)	63.13 (43.57-98.04)	<.001
	Flow	20.39 (0.21-98.58)	23.00 (1.44-174.86)	.006

ATA, Anterior tibial artery; *PA,* peroneal artery; *PTA,* posterior tibial artery.
sO_2 values are percentages; flow values are in arbitrary units (AU). Significance testing by Wilcoxon rank test.

Table IV. Comparison of the overall preinterventional and postinterventional microcirculation parameters of the foot

	Parameter	Preinterventional, median (range)	Postinterventional, median (range)	*P* value
DR angiosomes	sO_2	43.94 (1.00-95.99)	59.82 (3.79-98.04)	.004
	Flow	24.03 (0.16-70.23)	36.90 (2.47-123.01)	.007
IR angiosomes	sO_2	47.33 (10.98-72.34)	62.96 (8.88-84.58)	.005
	Flow	19.60 (0.06-140.70)	29.44 (4.37-179.74)	.013

DR, Direct revascularized; *IR,* indirectly revascularized.
sO_2 values are percentages; flow values are in arbitrary units (AU). Significance testing by Wilcoxon rank test.

For comparison of the changes separately in the DR and IR angiosomes, the differences between the preinterventional values and the measurement during dilation (difference Pre-Int) as well as between the postinterventional values and the measurement during intervention (difference Post-Int) were calculated. The comparison of the median of the differences showed no significant differences between DR and IR angiosomes (Table VI). Contradicting our hypothesis, a decrease of flow and sO_2 during time point Int (balloon inflation) was seen not only in the DR angiosomes but also in the IR angiosomes.

DISCUSSION

To the best of our knowledge, this study is the first one monitoring the immediate changes on the level of skin microcirculation continuously during and after the course of a tibial endovascular procedure using the combined laser Doppler flowmetry and white light spectroscopy method. This method has already proved to be feasible in measuring changes after revascularization, directly postinterventionally as well as during a follow-up period of 12 weeks.[2] It was demonstrated that an improvement of the macrocirculation also leads to an improvement of the microcirculation. However, the evaluation of the angiosome-oriented effects of revascularization showed no differences between DR and IR angiosomes in this previous study. Nevertheless, the heterogeneity of applied therapeutic strategies as well as the mixed patient collective limited the value of this previous study.[2] Therefore, we included only patients with tibial angioplasty in the present study, and further differentiation was made concerning the individual risk profile of each patient.

Hereby, we found a postinterventional improvement of the overall microcirculation of the foot. Furthermore, we were able to demonstrate an improvement of both the DR and the IR angiosomes. A comparison between the DR and IR angiosomes showed no significant differences. These results are in accordance with findings of our previous studies as well as with several studies evaluating the influence of the selected bypass target artery on wound healing.[2,8,27] For example, Azuma et al[8] could not find a significant difference concerning wound healing and limb salvage for DR angiosomes after tibial bypass surgery. However, these results are in contradiction to several retrospective findings of recently published studies.[2] Spillerova et al[16] showed a significantly better wound healing and limb salvage rate after angiosome-targeted revascularization in 744 patients. However, a summarizing review article of Sumpio et al was unable to detect a clear tendency; only half of the included studies showed a significant increase of the limb salvage rate for direct vs indirect revascularization (five of eight reported a better wound healing rate).[17] Furthermore, Varela et al[15] compared

Table V. Comparison of the median of the differences between the directly revascularized (*DR*) and indirectly revascularized (*IR*) angiosomes at investigation

	Parameter	DR angiosomes, median of difference (range)	IR angiosomes, median of difference (range)	*P* value
Overall	sO_2	15.97 (−27.80 to 71.09)	9.43 (−15.01 to 46.60)	.399
	Flow	9.35 (−25.92 to 107.98)	8.51 (−54.97 to 149.46)	.909
Diabetes	sO_2	13.14 (−17.22 to 59.40)	9.41 (−15.01 to 32.12)	.445
	Flow	8.05 (−25.92 to 107.98)	7.17 (−7.78 to 149.46)	.758
Nondiabetes	sO_2	20.99 (−27.80 to 71.09)	9.44 (3.04-46.60)	.859
	Flow	17.04 (−22.70 to 36.72)	9.85 (−54.97 to 138.88)	.953
Renal failure	sO_2	14.50 (−27.80 to 71.09)	9.43 (−15.01 to 28.97)	.246
	Flow	10.07 (−25.92 to 107.98)	12.56 (−54.97 to 149.46)	.691
Non-renal failure	sO_2	17.79 (−21.45 to 31.61)	12.22 (0.00-46.60)	.790
	Flow	6.80 (−22.70 to 37.80)	4.35 (−16.08 to 138.88)	.534

sO_2 values are percentages; flow values are in arbitrary units (AU). Significance testing by Wilcoxon rank test.

Table VI. Changes during balloon inflation and deflation by comparison of the median of the differences between the directly revascularized (*DR*) and indirectly revascularized (*IR*) angiosomes: preinterventional (*Pre*), during balloon inflation (*Int*), and postinterventional (*Post*)

	Parameter	DR angiosomes, median of difference (range)	IR angiosomes, median of difference (range)	*P* value
Pre-Int	sO_2	1.57 (−32.15 to 67.38)	3.01 (−27.36 to 39.27)	.633
	Flow	0.16 (−125.53 to 58.57)	0.32 (−53.05 to 109.33)	.879
Post-Int	sO_2	12.42 (−10.13 to 43.20)	10.27 (−14.56 to 54.56)	.236
	Flow	8.94 (−148.23 to 75.61)	12.20 (−25.81 to 170.87)	.395

Int, Time period of 10 seconds directly before balloon deflation; *Post,* 60 seconds at the end of intervention; *Pre,* baseline calculated out of 60 seconds before beginning of the intervention.
sO_2 values are percentages; flow values are in arbitrary units (AU). Significance testing by Wilcoxon rank test.

angiosome-targeted revascularization with ulcer blood flow restoration through collateral vessels in the chronic ischemic foot and came to similar wound healing rates after 12 months in addition to similar limb salvage rates. This may indicate that a chronic ischemic situation of the foot leads to a wide collateralization between the different angiosomes, which may lead to a reorganization of the angiosome borders. In addition, so-called choke vessels—linking intradermal vessels connecting the separate angiosomes—might carry a higher blood flow in the state of chronic limb ischemia. This means that the classical angiosomes as described by Taylor might not equally apply to patients with long-standing ischemic disease. In the vascular compromised foot, collateral flow may keep the ischemic angiosome vascularized to some extent as the original vasculature changed to an alternative arterial-arterial connection as reported by Osawa et al.[28]

Our study data indicate similar results as no differences between direct and indirect revascularization could be obtained. Therefore, we could not verify the relevance of the angiosome-targeted revascularization on the level of microcirculation.

Several studies noted a higher importance of the angiosome-targeted revascularization in patients with renal insufficiency as well as in patients with long-term diabetes mellitus, as diabetic as well as renal insufficiency patients are known to have a poor vascular collateralization in the periphery.[14,29] Therefore, we subdivided our patient collective into diabetics and nondiabetics as well as renal insufficiency and non-renal insufficiency. Contrary to our expectations, no significant differences concerning the microcirculation between direct and indirect revascularization were recognized in our results.

As described in various studies, the nutritional function of microcirculation seems to be the main factor responsible for a sufficient ulcer healing.[30,31] Accordingly, it seems to be essential to achieve a maximum of improvement of the microperfusion in the ischemic foot. As this study has shown, tibial endovascular intervention grants a significant improvement of overall foot skin microcirculation. However, the microcirculatory improvement seems to be global and not restricted to borders, such as described by the classical angiosome concept.

Finally, this study was limited by the relatively small study population (30 patients). By comparing the absolute values of the median of the differences of the parameters sO_2 and flow, the difference of sO_2 seems to be wider in the DR group than in the IR group, which has not proved to be significant (Table V). Therefore, it might be necessary to conduct a study with a larger study population to evaluate whether this effect remains constant.

CONCLUSIONS

There is a significant improvement of tissue perfusion of the foot immediately after tibial angioplasty. The effect shown in this study was found to be global and not restricted by certain borders, as defined by the angiosomes.

AUTHOR CONTRIBUTIONS

Conception and design: UR, WL, RH, AM
Analysis and interpretation: UR, KK
Data collection: UR, KK, AS, MH, AM
Writing the article: UR
Critical revision of the article: UR, WL, RH, AS, MH, AM, SR
Final approval of the article: UR, KK, WL, RH, AS, MH, AM, SR
Statistical analysis: UR, SR
Obtained funding: Not applicable
Overall responsibility: UR

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INVITED COMMENTARY

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Although few would argue that revascularization is the cornerstone of treatment for symptomatic peripheral arterial disease, multiple questions about its execution remain unanswered. One such question relates to what tibial target vessel is best revascularized. Traditionally, surgeons chose the target vessel for a surgical bypass based on gestalt rooted in a series of qualitative features, including adequate diameter, length, freedom from calcification, and direct connection to a named foot vessel.

Paramount to the choice of revascularization target was its anticipated technical suitability for a surgical anastomosis. Advent and adoption of endovascular therapy, with associated lack of relevance for surgical target suitability, has brought into question the traditional concepts of the optimal distal target. Serendipitously, the angiosome concept, applied to the lower extremity, offered a rational approach on which to base target choice.

It is intuitive to imagine that revascularizing a target vessel that directly supplies the tissue in most need of improved blood flow makes sense. Multiple studies testing this concept concluded that angiosome-targeted revascularization leads to better wound healing and limb salvage rates than indirect revascularization. There is also evidence that the effect of angiosome-directed revascularization may differ across surgical and endovascular treatment strategies.

In their study, Rother et al evaluated the effect of angiosome-based endovascular revascularization on foot circulation. They prospectively measured changes after angiosome-directed and indirect tibial angioplasty in foot macrocirculation using ankle-brachial index and microcirculation using laser Doppler flowmetry and tissue spectrometry. The authors discovered that although there was global improvement in both foot macrocirculation and microcirculation after treatment, there was no differential improvement in specific angiosome microcirculation based on whether revascularization was angiosome directed or not. The presence of diabetes or renal failure did not change these observations. There is no question that this study can and will be criticized for its relatively small numbers and vagaries of design. However, the authors' findings cast a shadow over the presumption that angiosome-based revascularization is crucial.

That the story of optimal revascularization is more complicated than it appears is not surprising. Collateral circulation formed in response to chronic ischemia may lead to better transangiosomal flow than would be anticipated. This fits with the clinical observation that bypass to one part of the foot may successfully treat tissue loss in another. As the authors point out in their discussion, not all studies evaluating the angiosome concept reached the conclusion that angiosome-directed revascularization is essential. Furthermore, many studies supporting the utility of angiosome-directed revascularization may be criticized for small numbers, retrospective design, and lack of adequate covariate adjustment. The Best Endovascular vs Best Surgical Therapy in Patients With Critical Limb Ischemia (BEST-CLI) and Bypass versus Angioplasty in Severe Ischaemia of the Leg (BASIL) 2, prospective, randomized controlled trials evaluating revascularization strategy for critical limb ischemia and currently accruing patients in North America and Europe, may allow for secondary analysis of angiosome-directed vs indirect revascularization and thus provide more data to this controversy. In the meantime, there is no harm in considering angiosomes as one of a number of factors that weigh on the choice of the revascularization target.