Surgical treatment of varicose veins with the CHIVA method

Operative Behandlung der Varikose nach der CHIVA-Methode

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ABSTRACT

In 1988, just after the upcoming of duplex ultrasound, the French vascular surgeon and angiologist Claude Franceschi developed a hemodynamic strategy to treat venous insufficiency on ambulatory patients. He gave the treatment the name of the French acronym. CHIVA.
The strategy is based on the preservation of draining pathways, specially the saphenous veins. The first step consists in an analysis of the recirculation pathway, which was classified by Franceschi into veno-venous shunts, depending on the reflux source and the drainage. Each shunt type requires a special way of treatment to achieve the best result and to avoid superficial thrombosis. The method has found its place in the treatment options in Spain and Italy, actually it is becoming popular in CHINA and the European Eastern Countries, especially in countries, where duplex is common in phlebology diagnostics and financial resources are small.
The method can be applied in each degree of venous illness and chronic venous insufficiency, excepting post-thrombotic saphenous trunks, which might not need to be preserved. A meta-analysis in a Cochrane review certifies that CHIVA produces less side effects and long term recidives with the same immediate results as stripping.
New techniques, like endoluminal (heat) procedures and ultrasound guided foam sklerotherapy help to make the procedure even less invasive in the future.

ZUSAMMENFASSUNG

Im Jahr 1988, kurz nach der Einführung der Duplex-Sonographie, entwickelte der französische Gefäßchirurg und Angiologe Claude Franceschi ein venenerhaltendes Verfahren zur Behandlung insuffizienter Stammvenen bei ambulanten Patienten – ein Verfahren das er nach dem Akronym aus dem Französischen als „CHIVA“ bezeichnete.
Es handelt sich um eine Strategie zum Erhalt der Drainagewege, insbesondere der Stammvenen, im Bein. Sie erfordert eine Analyse der Rezirkulationkreise, die Franceschi je nach Ursprung des Refluxes und seiner Drainagewege in Shunts einteilte. Jeder Shunt bedarf einer eigenen Herangehensweise, um eine stabile postoperative Situation zu erhalten und oberflächliche Venenthrombosen zu vermeiden. Das Verfahren hat sich in Italien und Spanien durchgesetzt, im Moment hält es seinen Einzug in China und in den osteuropäischen Ländern, primär dort, wo der Duplex als Grundlage für die phlebologische Diagnostik zählt und eine kostengünstige Herangehensweise vom Gesundheitswesen gefordert wird.
Das Verfahren kann bei jeder Ausprägung der Varikose und jedem Stadium der chronischen venösen Insuffizienz angewendet werden, wobei der Erhalt einer postthrombotisch veränderten Stammvene nicht anstrebenswert erscheint. Eine Metaanalyse (Cochrane-Review) bescheinigt CHIVA weniger Rezidive bei gleichwertigem Erstergebnis und weniger Nebenwirkungen im Vergleich zum Stripping, wobei weitere Studien mit höheren Patientenzahlen gefordert werden.
Die neuen Techniken, wie endoluminale (Hitze-) Verfahren und schallgesteuerte Schaumverödung haben das Verfahren noch minimal-invasiver gemacht, sodass die ohnehin geringe Komplikationsrate und die kurze Arbeitsunfähigkeitszeit noch verkürzt werden kann.

Introduction

Until the 1980 s, there was only one surgical technique for the treatment of trunk vein insufficiency: high ligation and stripping. The strategic consideration behind the stripping procedure was to remove the diseased vein. The procedure was progressively refined and became much less traumatic with the introduction of invaginated stripping and an approach that took the length of reflux in saphenous vein into account [1]. Duplex sonography as the diagnostic method of choice for varicose veins also provides guidance during the therapeutic procedure and has therefore changed treatment options regarding the tactic of 'eliminating the vein'. Without ultrasonography, ultrasound-guided sclerotherapy, endovenous thermal procedures and extraluminal valvuloplasty would not have been possible.

Duplex ultrasonography has also altered our understanding of the haemodynamics of varicose veins, allowing us to establish the direction of flow and analyse the recirculation pathways – aspects that had been discussed in theory by Trendelenburg and Hach, but never determined in detail or comprehensively for each individual patient.

This analysis allowed Dr Claude Franceschi to classify the recirculation according to the origin of the reflux, its pathway and its drainage in terms of 'shunts' [2]. His strategy was to then interrupt the recirculation without removing the vein – with the aim of preserving a functioning trunk vein without disconnecting any venous drainage channels for blood from the skin.

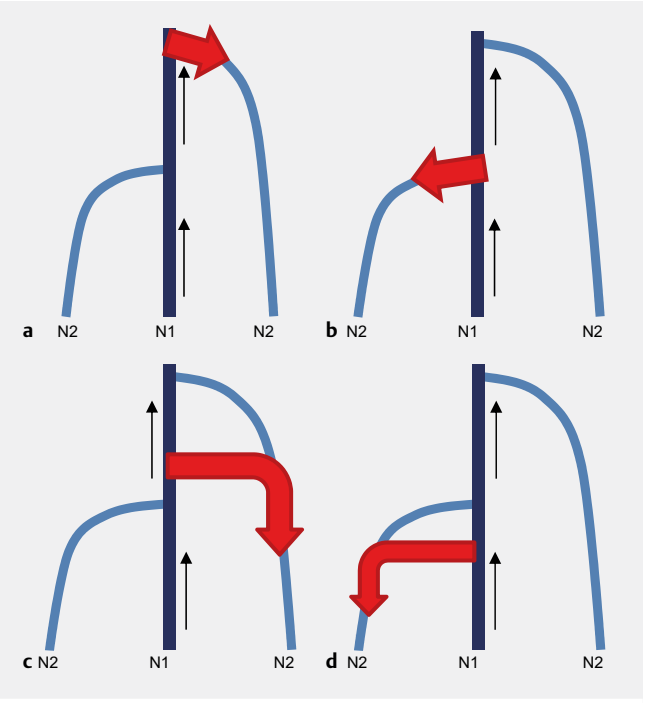
Since 1988, the first theoretical approach has been progressively developed by findings from clinical practice. At the beginning, only surgical techniques were used. But over time other methods such as sclerotherapy and endovenous thermal ablation were then called upon, provided they did not destroy the saphenous vein [3].

This article explains the strategy and addresses the possible state-of-the-art surgical techniques for its implementation.

Franceschi shunt classification

Ultrasonography showed that the trunk veins (the great and small saphenous veins) run in a fascial compartment, which differentiates them from other superficial leg veins. Franceschi divided the leg veins into networks – the deep venous network (N1), the trunk veins of the 'interfascial' network between the muscle fascia and the saphenous fascia (N2) and the 'epifascial' veins (N3) [2, 4]. Blood draining from the leg usually flows from superficial to deep, i. e. from a higher numbered network (N3, the superficial network) into a lower numbered network (N2, the interfascial network, or N1, the deep network). Reflux is present when the direction of the flow is reversed.

Franceschi subdivided the shunts according to the networks concerned and the order, in which they are involved, i. e. the source of the reflux and the drainage pathway. As reflux sources, he considered the reflux N1 → N2 (reflux from the deep veins into the trunk veins, ▶ **Fig. 1**) or from other sources (reflux from a perforating vein into a tributary vein, ▶ **Fig. 2**, then flowing into the trunk vein (N1 → N3 → N2) or from pelvic reflux sources (e. g. veins physiologically draining at the confluence of superficial inguinal veins, in German also known as the *Venenstern*, as shown in ▶ **Fig. 3**). He regarded drainage from the trunk vein into the deep leg vein via



▶ **Fig. 1** Reflux sources from the deep venous system (N1) into the trunk vein, whether across the saphenofemoral junction (**a**), across the saphenopopliteal junction (**b**), via a perforating vein into the great saphenous vein (**c**) or into the small saphenous vein (**d**).

a perforating vein (N2 → N1, ▶ **Fig. 4a**) or via a tributary vein connecting to the perforating vein (N2 → N3 → N1, ▶ **Fig. 4b**) as reentry pathways. In order to distinguish between the two pathways, Franceschi and Cappelli developed the reflux elimination test (see ▶ **Fig. 4c**) [5, 6].

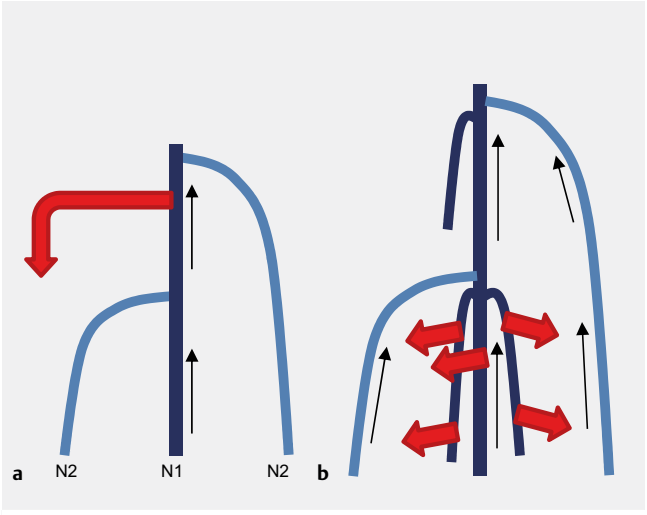
The most common shunts are those, in which the reflux passes from the deep veins, N1, directly into the trunk veins, N2 (N1 → N2), usually across the saphenofemoral or saphenopopliteal junction and more rarely via perforating veins [5].

In a Type 1 shunt (reflux N1 → N3), blood drains from the trunk vein directly to the deep leg vein via a perforating vein (N2 → N1) (▶ **Figures 4a** and ▶ **Figures 4c** and ▶ **Fig. 5**, top left). A Type 3 shunt also has N1 → N2 reflux, but there is no draining perforating vein to be found on the trunk vein. The drainage pathway requires a tributary vein: N2 → N3 → N1 (▶ **Figures 4b** and ▶ **Figures 4c** and ▶ **Fig. 5**, top right).

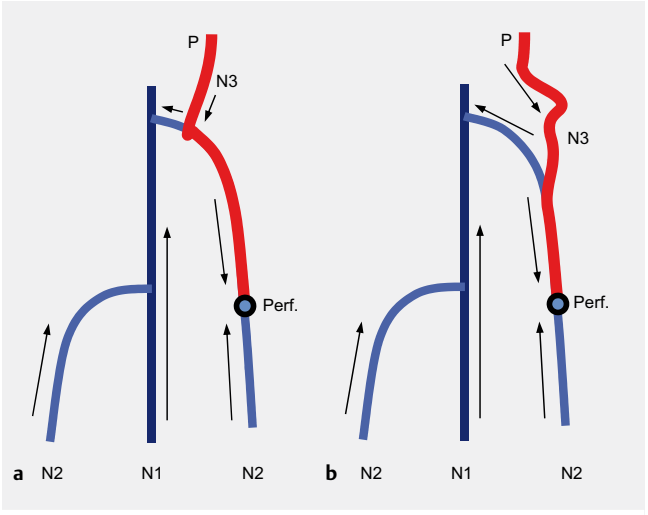
If the reflux originates from a pelvine tributary that opens at the confluence of superficial inguinal veins or comes from a perforating vein and a tributary into the trunk vein, i. e. a tributary vein is connected between the perforating vein and the trunk vein, we refer to Type 4 or Type 5 shunts, depending on the drainage pathway. Does the flow travel from the saphenous vein to the deep vein directly via a perforating vein (Type 4, ▶ **Fig. 3**) or is a tributary vein involved (Type 5, ▶ **Fig. 7**)?

CHIVA treatment strategy

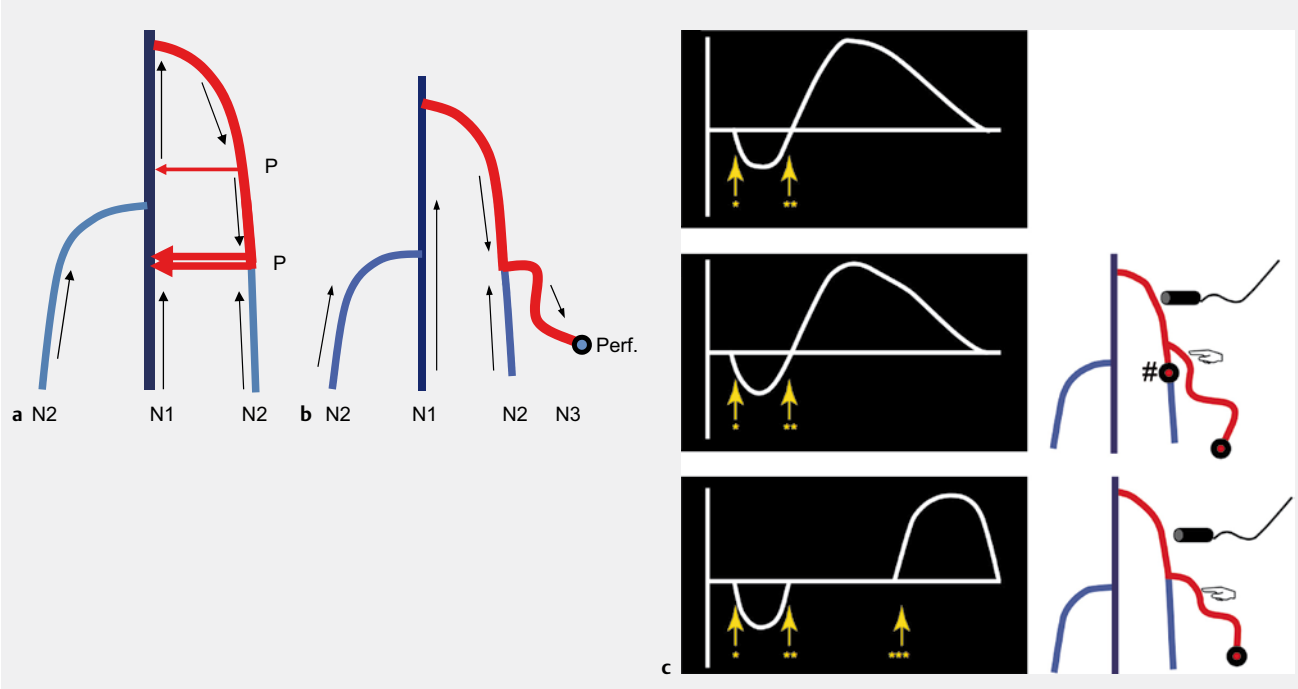
Ambulatory conservative hemodynamic correction of venous insufficiency (CHIVA) aims to interrupt the recirculation pathway without removing the trunk veins. This aim can essentially be achieved



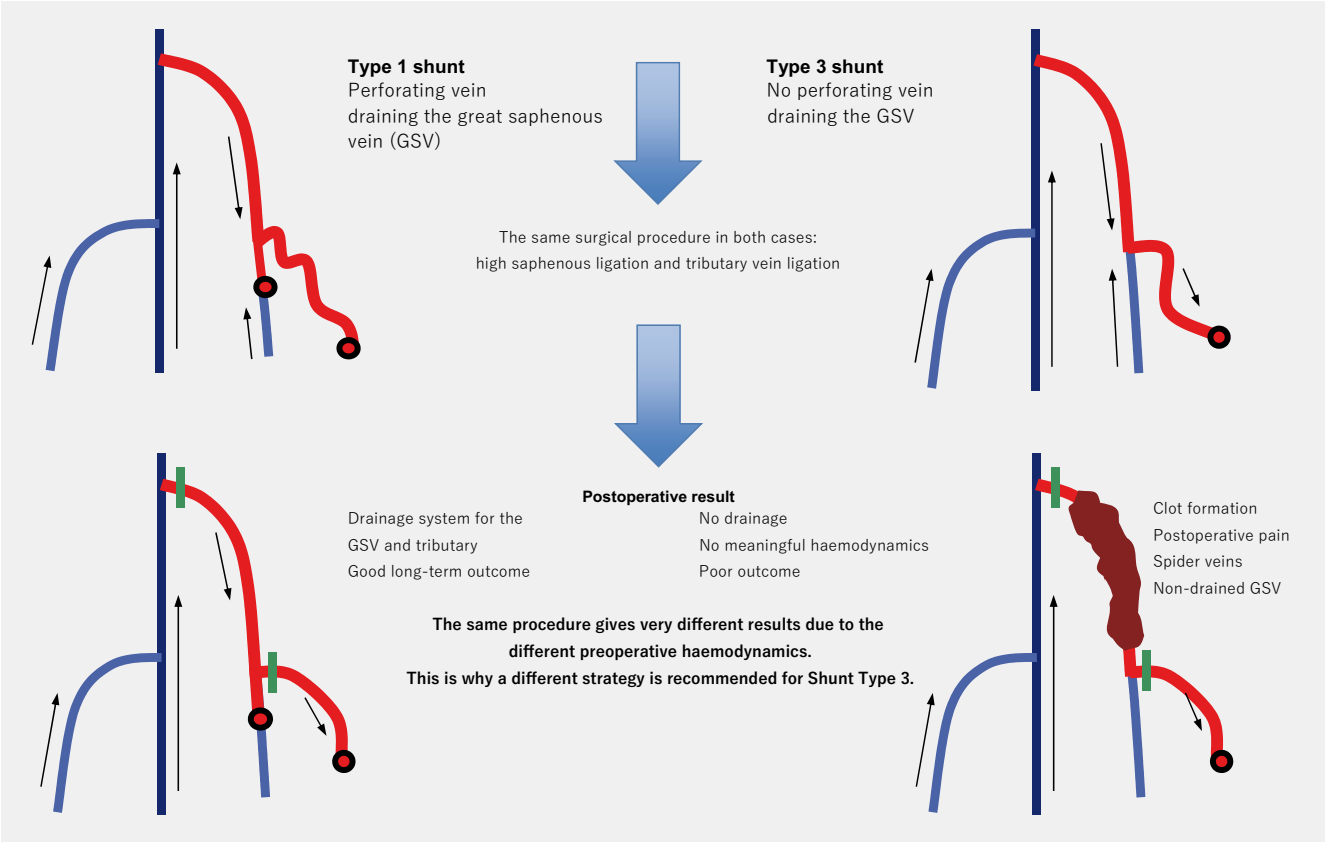
▶ **Fig. 2** Reflux sources from the deep venous system into tributary veins (N3) via perforating veins, either in isolation, as is often seen on the back of the thigh (**a**), or via several perforating veins in the calf (**b**). In the case of a healthy deep venous system, we see this only after trauma, e. g. an injury in young people playing football without any protection of the calf.



▶ **Fig. 3** Reflux sources from the pelvis with an incompetent pelvic vein network as points of reflux to the leg, such as the inguinal or perineal reflux point (P). They fill tributary veins (N3), which in turn may join the trunk vein, either directly in the groin via a superficial inguinal vein opening at the confluence (**a**) or more distally via a tributary vein that can usually be seen beneath the skin on the medial or anterior aspect of the thigh (**b**).



▶ **Fig. 4** **a** Drainage pathway from the trunk vein (N2) directly to the deep leg vein (N1) via a perforating vein. There is usually only one draining perforating vein (P, double arrow) that carries the whole volume to the deep leg veins, however, there may be several dilated veins, which also serve as re-entry points (P, single arrow). This situation corresponds to a Type 1 shunt with reflux from the deep leg veins into the trunk vein and drainage back to the deep leg vein. Refluxing downstream tributary veins may also be present. **b** Drainage pathway from the trunk vein via a tributary vein. On the trunk vein itself, we can find no dilated perforating vein that could drain the reflux volume. **c** Zamboni's reflux elimination test (RET). Top: the flow curve in a refluxing trunk vein under a provocation manoeuvre and no other external influences (toes raised*, toes lowered again**). Middle: digital compression of the tributary vein without simultaneous compression of the trunk vein. Ultrasound transducer between the groin and the tributary vein. A draining perforating vein connects with the trunk vein (black circle filled in red #). The flow curve is not affected by compressing/interrupting the tributary vein: drainage of the trunk vein occurs independently of the tributary vein – Type 1 shunt. Bottom: digital compression of the tributary vein stops reflux into the trunk vein until we release the tributary vein again (***), because the reflux does not drain from the trunk vein without this tributary vein – Type 3 shunt.



▶ **Fig. 5** The same strategy (high ligation and tributary vein ligation) with different preoperative haemodynamics: Type 1 shunt and Type 3 shunt.

by disconnecting the source of reflux, i. e. stopping the pathological transfer from a smaller N to a larger N.

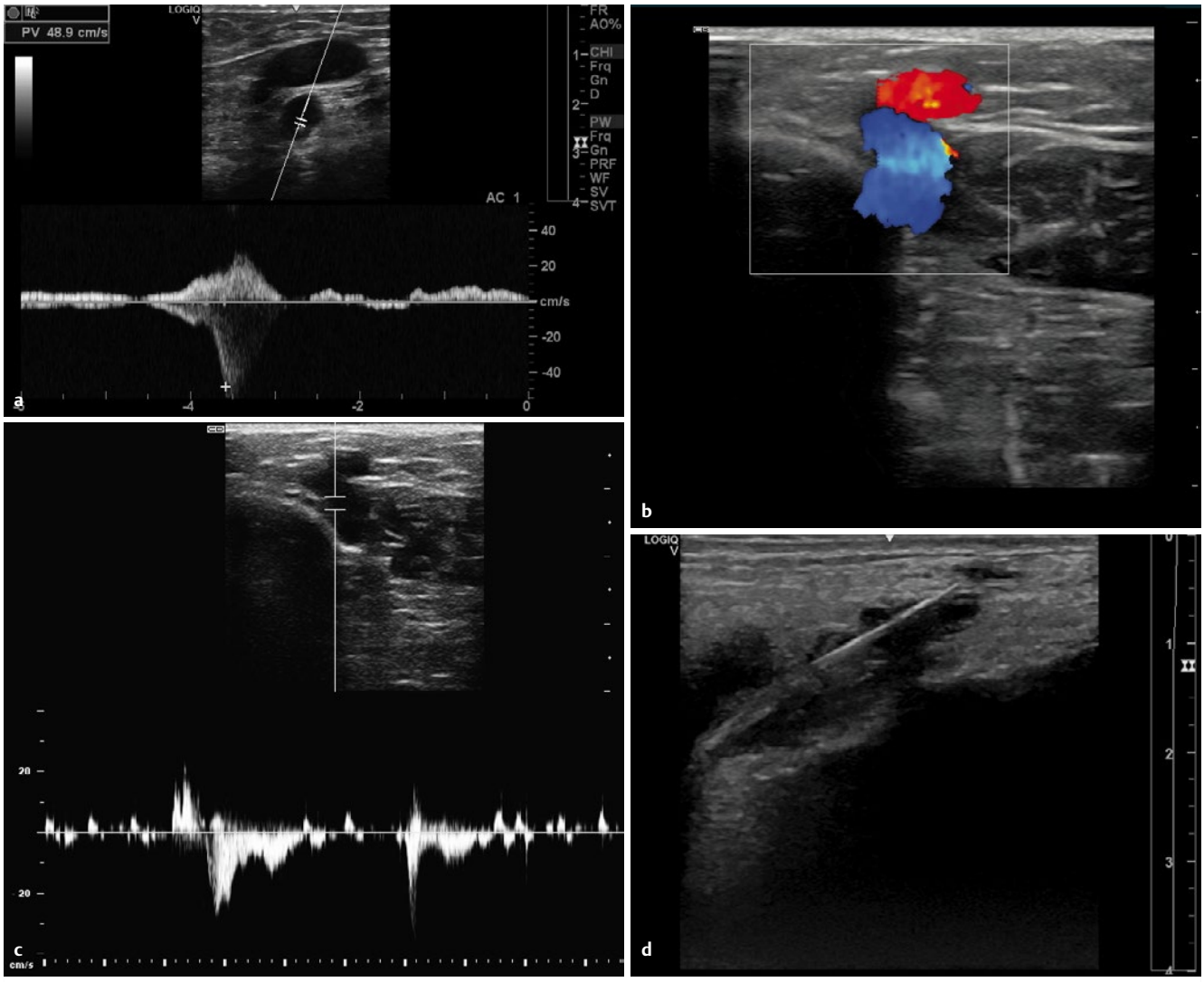
Treatment of the saphenofemoral junction

In the case of reflux at the saphenofemoral junction, high saphenous ligation would be the obvious therapeutic step. As with all ablative procedures for varicose veins, this is the region with the most recurrences. Many different procedures and techniques have therefore been developed, such as isolated ligation with non-absorbable suture material, ligation with additional titanium clips, conventional extensive ligation of the saphenofemoral junction without stripping and the endovenous thermal ablation of 7–10 cm in the region of the saphenofemoral junction [7, 8, 9, 10]. In Germany, because of the possible statutory health insurance reimbursement according to the fee schedule (*Uniform Evaluation Scale, EBM*), only conventional SFJ ligation of the sapheno-femoral junction and all the tributaries or the alternative endovenous occlusion of a short segment distal to the confluence of superficial inguinal veins come into question at this point. A very favourable side effect of short endoluminal ablation distal to the groin tributaries for CHIVA in comparison with extensive saphenofemoral junction ligation is that it continues to allow drainage from the pelvic veins through confluence to the deep leg vein. If additional distal reflux from the saphenous vein into a tributary vein is present, it can be interrupted flush at the level of the trunk vein, either at the same time or at a later date, depending on the individual situation.

However, this is not the only criterion on which the decision is based. Simultaneous ligation of the great saphenous vein and the tributary vein gives very good long-term results with Type 1 shunts [11, 12, 13]. But this is not the case with Type 3 shunts, as superficial venous thrombosis, spider veins on the thigh and a non-draining situation may develop postoperatively, giving rise to the same haemodynamic results as we see after stripping (see ▶ **Fig. 5**). For this reason, analysis of the re-entry point is extremely important. If a perforating vein is draining the trunk vein, high saphenous ligation and tributary vein ligation will bring sustained success. If there is no draining perforating vein on the saphenous trunk, the first step is to interrupt the tributary vein, as high ligation alone will lead to persistent tributaries. Alternatively, high ligation may be performed and the tributary vein can be ligated or sclerosed after reduction in diameter [14].

Treatment of incompetent perforating veins

First of all, it has to be stated that perforating veins are only incompetent in terms of recirculation when they fill the varicose veins. We can establish this fact with an ultrasound scan examining the perforating vein in pulsed wave (PW) mode. In diastole – the relaxation phase following a provocation manoeuvre – the blood flow in an incompetent perforating vein must be directed outwards (see ▶ **Fig. 6a**) [22]. We can then say that there is reflux and the vein is ‘guilty’ in terms of the recirculation [23]. However, if we find that the blood in a dilated perforating vein flows towards the deep vein,



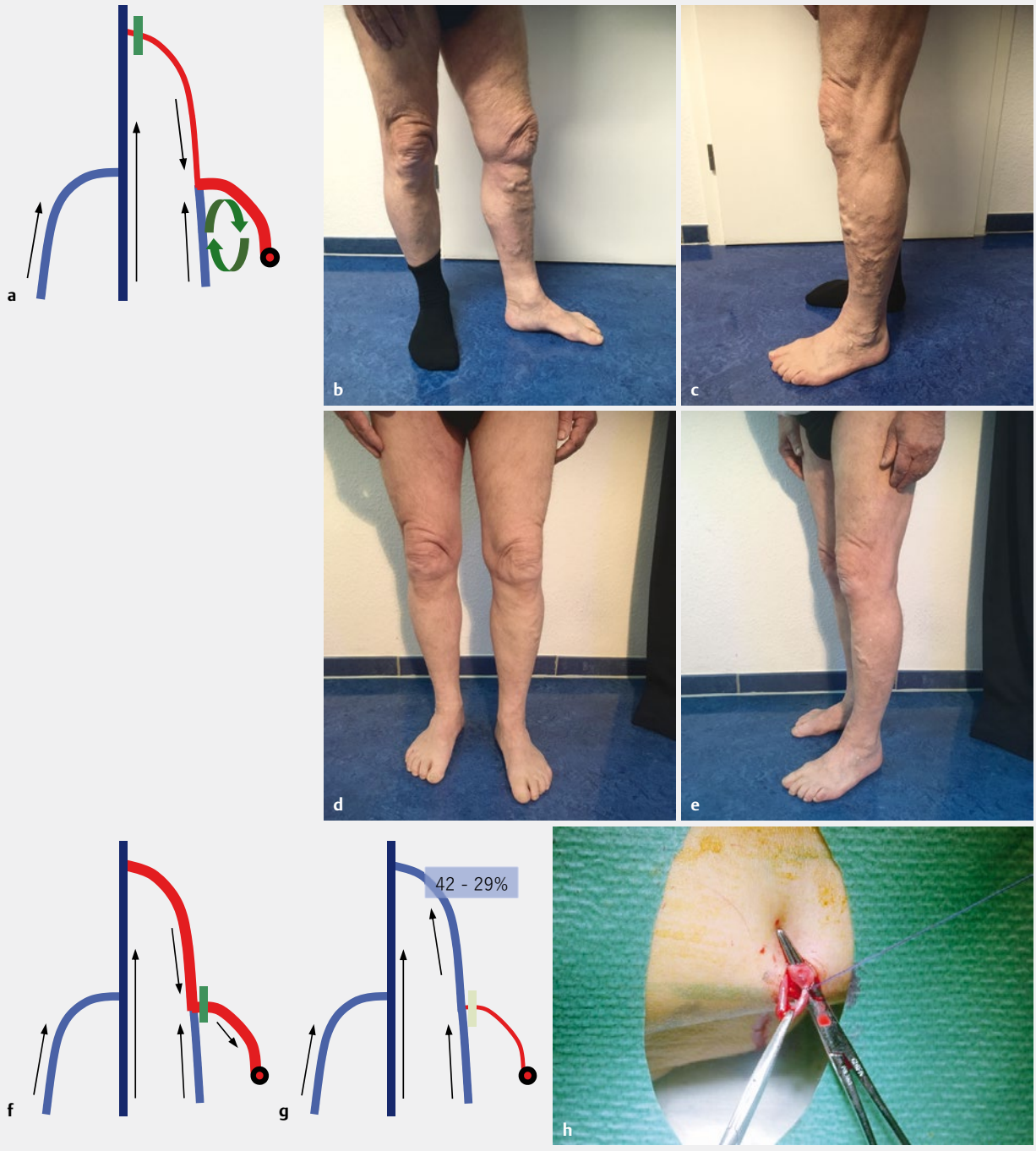
▶ **Fig. 6** **a** Longitudinal section through the medial aspect of the thigh showing a refluxing perforating vein: the PW measurement is made in the perforating vein and clearly demonstrates outwards flow from the deep leg vein to the superficial trunk vein. **b** Transverse section below the knee on the medial aspect of the calf; the edge of the tibia can be seen at the left side of the image. The transverse section of the great saphenous vein is coloured red and the perforating vein through which the reflux volume drains to the deep vein is coloured blue. **c** The same site in PW mode. Measurement in the perforating vein clearly shows that the blood flow is draining from superficial to deep. **d** Oblique section of the proximal medial aspect of the calf. A (400 µm) laser probe can be seen in the lumen of a refluxive perforator.

this dilated vein is part of the recirculation drainage and, according to the CHIVA strategy, should therefore not be touched (see ▶ **Figures 6b** and ▶ **Figures 6c**).

When reflux from a perforating vein is present – whether it flows directly into the trunk vein or into a tributary vein – interruption of the perforating vein will cut off the source of the reflux. This interruption can be performed surgically, using an endovenous laser technique when the perforating vein runs straight (see figure 6 d) [15] or foam sclerotherapy, if the perforating vein is thin [10, 14, 15].

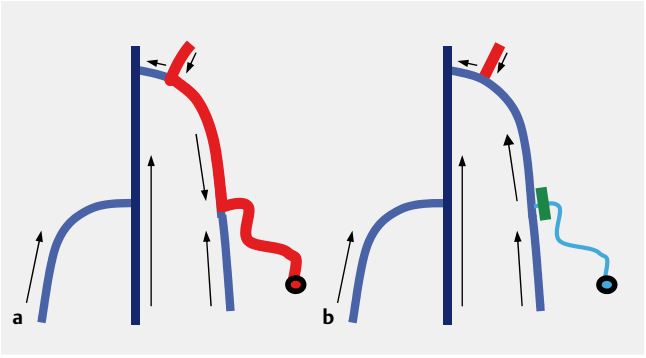
Treatment of tributary veins

The preservation of tributary veins is not the aim of CHIVA. Phlebectomy of tributaries is therefore not inconsistent with CHIVA procedures. However, the associated trauma is often unnecessary, as the tributary veins frequently disappear after the reflux in the trunk vein has been reduced. In the case of a Type 1 shunt, there is an optimal therapeutic situation: the source of reflux from the deep vein into the trunk vein (usually the saphenofemoral or saphenopopliteal junction) is closed and all refluxing tributary veins can be disconnected at their confluence with the trunk vein. The flow still present in the trunk vein drains into the re-entry perforating vein and the tributary veins are no longer filled pathologically (see ▶ **Fig. 5**, left). But this is not the solution for a Type 3 shunt (see ▶ **Fig. 5**, right). If the saphenofemoral junction and the tributary vein are disconnected in this case, thrombosis will occur in the trunk vein between the two. Type 3 shunts are therefore more problematic. If only the saphenofemoral junction is disconnected leaving the tributary vein, the distal great saphenous vein will continue to fill the tributary vein, which regresses, but does not disappear from view (see ▶ **Figures 7a–▶ Figures 7f**). It can usually then be sclerosed at a later date, if so desired. In cases where the proximal great sa-



▶ **Fig. 7** **a** Situation after disconnecting the saphenofemoral junction in a Type 3 shunt (cf. ▶ **Fig. 5**, top right). Even though the trunk vein is reduced in diameter, there is not only retrograde filling of the tributary vein from the proximal trunk, but also flow into the tributary vein from the distal trunk. Although it is somewhat thinner, the tributary has not disappeared cosmetically. High ligation alone has improved the patient's clinical picture in this case (cf. b–e and f); **b–e**: Two images on the left (**b, c**) before and two images on the right (**d, e**) three months after high ligation in a Type 3 shunt analogous to image **a**. Regression of the tributary varicose vein as much as possible: the patient did not want any further treatment; **f** CHIVA 2 strategy to disconnect the tributary vein from the trunk vein as the first step, without any treatment of the saphenofemoral junction; **g** Reversal of flow in the trunk vein in 42 % of cases after one year, still present in 29 % after three years; **h** Detailed image of a tributary vein disconnected from the trunk vein: the vessel is ligated flush with the trunk vein, even though it requires a somewhat larger skin incision to dissect out the course of the great saphenous vein beneath the saphenous fascia.

phenous vein is of a small diameter, the tributary vein can first be interrupted: this leads to reversal of flow in the trunk vein in 42 % of cases, which lasts for one year and is still present after three years in 29 % (see ▶ **Fig. 7f**) [6]. Surgery must ensure that the tributary is disconnected cleanly from the trunk vein, otherwise there will be an early recurrence (see ▶ **Fig. 7g**).



▶ **Fig. 8** Type 5 shunt – reflux from the pelvis into the trunk vein with a competent terminal valve (Stücker type 2). Drainage through a tributary vein (no reflux in the RET, when compressing the tributary vein. **a** Preoperative situation; **b** Situation after tributary vein disconnection. Regression of the tributary vein. Stable reversal of flow in the great saphenous vein with antegrade flow in 97 % after three years. The reflux from the pelvis drains to the deep veins through the saphenofemoral junction.

The optimal situation for isolated tributary vein ligation with the aim of reversing the flow in the trunk vein is a Type 5 shunt – the terminal valve is competent and there is no draining perforating vein on the trunk vein (see ▶ **Fig. 8a**). After disconnecting the tributary vein flush with the trunk vein, a sustained stable reversal of the flow is achieved in 97 % of cases (see ▶ **Fig. 8b**).

Pelvic reflux

We often find incontinent pelvic networks after pregnancy, after surgical procedures in the pelvis or when there is a varicocoele. The pelvic network is surrounded by fascia – there are only a few connections with the superficial venous system of the leg. One is across the inguinal canal, another through perineal veins, which lie superficially in the labia and are often considerably dilated during pregnancy. Delfrate and Franceschi developed specific minimally invasive surgical techniques to interrupt these points at the fascial level (16).

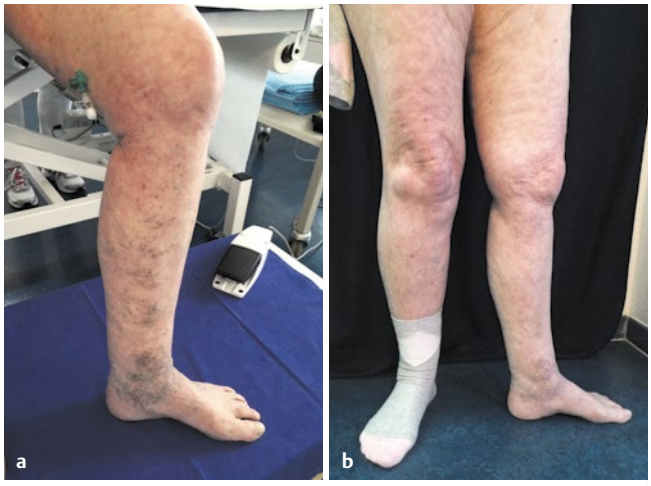
Results

Time and again it is said of CHIVA that there are no results or long-term studies. Three randomised trials on CHIVA vs stripping are included in a Cochrane Review; they have a follow-up period of 5–10 years. This confirms that CHIVA has similar initial results with fewer side-effects. The recurrence rate is considerably lower in the CHIVA group [11, 12, 17, 18].

In addition, there are studies on individual situations such as ‘CHIVA 2’, i. e. interruption of a tributary vein [6] or reduction in the diameters of the trunk vein and the deep veins and improvement of measurable parameters such as photoplethysmography [8, 13, 19]. The chapter CHIVA: Results from the literature [20] gives an up-to-date overview.

Summary

CHIVA is a surgical strategy to preserve the trunk vein as a drainage pathway. High ligation and tributary vein disconnection provide



▶ **Fig. 9** Left: Prior to endovenous therapy for saphenofemoral incompetence as single treatment – the intravenous canula is already in place. Clinically, the patient has C4 varicose veins with discoloration over the ankle as well as pain and a feeling of heaviness despite consistent compression therapy. Right: follow-up examination after three months. Persistence of multiple spider veins, but clear regression of the discolouration.

a good and sustained stable solution for the situation most commonly encountered in phlebology – namely reflux from the deep leg vein across the terminal and preterminal valves (Stücker type 3) with drainage via a perforating vein (Type 1 shunt, about 35 % of patients with an indication for surgery). For Type 5 shunts (reflux from the lesser pelvis with a competent terminal valve) – which is still the case in about 20 % of patients [21] – a complete flow reversal in the trunk vein can be obtained by merely interrupting the tributary vein. It also revolutionises the idea that refluxing trunk veins are permanently damaged and therefore not worth preserving, as many of our colleagues often assert.

High ligation alone or the endovenous ablation of 7–10 cm of the proximal vein in some situations can considerably improve the clinical picture – allowing patients with comorbidities or on full anticoagulation to be treated with clear symptomatic improvement and minimal side effects (see ▶ **Fig. 9**).

The new surgical techniques have made the whole procedure even less traumatic. Many of our colleagues are deterred from learning about the shunt types. However, the classification is actually quite easy – there are two possible sources of reflux and two possible drainage pathways that can be combined to give four types of shunt – thus establishing the rules for treatment. It would be desirable for more doctors to include CHIVA in their therapeutic spectrum for the optimal care of all patients.

Conflict of interest

The authors declare that they have no conflict of interest.

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