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# Improvement in Deep Vein Haemodynamics Following Surgery for Varicose Veins

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***Objective.*** *To analyse the effect of superficial and perforating veins surgery on deep vein incompetence.*
***Methods.*** *During a six-month period between 2000 and 2001 24 patients (32 limbs) with chronic venous insufficiency (CVI) were treated. They were selected because they had varicose veins and proximal deep vein incompetence with photoplethysmography (PPG) venous refilling time (VRT) <15 s with a below knee tourniquet, and a femoral or popliteal vein reflux time (RT) >1.5 s on duplex ultrasound. The group was divided according to aetiology into 21 legs with primary (Ep) and 11 with secondary CVI (Es). All patients underwent removal of varices with stripping of the saphenous veins, if appropriate. In 21 cases subfascial endoscopic perforating vein surgery (SEPS) was performed to ligate incompetent perforating veins.*
***Results.*** *The average VRT for the entire group increased from 9.8 s before to 15 s after operation ($p < 0.001$, paired t test). In the Ep group the average VRT increased from 11 to 18 s ($p < 0.001$, paired t test), in Es group from 7.5 to 10 s ($p > 0.001$, paired t test). Duplex ultrasonography before surgery showed femoral vein incompetence in 28 and the popliteal incompetence in 26 cases. The average femoral vein RT was 1.9 s before and 1.4 s after surgery ($p < 0.001$, paired t test). The femoral RT in the Ep group decreased from 1.9 to 1.3 s ($p < 0.001$, paired t test) and in the Es group from 1.9 to 1.6 s (N.S.). In the popliteal vein, RT was 1.8 s before, and 1.3 s after surgery ($p < 0.001$, paired t test). The RT in the Ep group shortened from 1.8 to 1.1 s ($p < 0.001$ paired t test) and in the Es group from 1.9 to 1.5 s (N.S.).*
***Conclusion.*** *Surgical treatment of varicose veins and of calf perforators results in reduced deep vein reflux. The improvement is most marked in cases of primary venous insufficiency.*

*Key Words: Varicose veins; Deep vein incompetence; Venous surgery; Valve incompetence; Venous haemodynamics.*

## Introduction

Deep vein incompetence is a serious and yet unsolved clinical problem. Deep vein reflux accompanying chronic venous insufficiency (CVI) worsens the prognosis and makes clinical management more difficult. Anti-reflux surgery—consisting in reconstructing venous valves, transplanting segments with competent valves, or venous transposition—is performed extremely rarely and in few centres around the world.[1–4] Good results seem more to depend on a subjective reduction of symptoms, with little haemodynamic improvement on plethysmographic tests. Some surgeons have found difficulty in replicating good results reported in published papers on reconstructive venous surgery, which is therefore, conducted on a very limited scale. It has been observed that in patients with combined superficial and deep vein incompetence standard varicose vein surgery reduces deep vein reflux.[5–11] This finding has led to hope that deep vein reconstruction can be avoided in some patients by simply treating superficial venous reflux and ignoring the deep vein incompetence. The aim of this study was to analyse the effect of superficial and perforating vein surgery on deep vein competence and to assess the influence of the aetiology of the CVI on the outcome of treatment.

## Materials and Methods

The clinical series reported in this paper was selected from 150 patients who were considered for surgical management for CVI during a six-month period between 2000 and 2001. Twenty-four patients were selected for investigation and treatment (32 limbs)—12 women and 12 men who had both deep and superficial venous reflux in the lower limb. The average age of patients was 57 years. The patients were included in

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the study if they had symptomatic varicose veins, a photoplethysmography (PPG) venous refill time (VRT) of less than 15 s with a below knee tourniquet, and with femoral or popliteal vein reflux demonstrated by duplex ultrasonography with a reflux time (RT) of more than 1.5 s.

The PPG VRT test was performed with the IMEXLAB 9000 according to an established protocol.[12] The patient sat with the PPG probe placed on healthy skin 10 cm above the medial malleolus. The patient then performed 10 dorsiflexions at the ankle to activate the calf muscle pump and expel blood from the leg veins. The patient then sat still and refilling of the leg veins was monitored. The time taken for the veins to refill is called venous refill time. The VRT is reduced in cases of venous reflux. In order to assess deep vein competence a 12 cm wide pneumatic cuff was positioned below the knee and inflated to 60 mmHg to occlude the superficial veins. The cuff remained inflated during the entire test and the results were considered to reflect the competence of deep vein valves. The venous refilling times were calculate by the Imexlab software.

Duplex ultrasound examinations were done with the following systems: Siemens Elegra with a 5.1–9 MHz wide–band linear array; ATL HDI 5000 with a 5–12 MHz wide-band linear array. Patients were examined in both lying and standing positions. The competence of the superficial femoral vein was assessed at three levels (upper, middle and lower part of the thigh). The competence of the common femoral vein above the sapheno-femoral junction (SPJ) was not assessed because the authors found difficulty in assessing this region reliably and it was often difficult to assess with the patients in the standing position.

The popliteal vein was assessed a few centimetres above and below the SPJ in order to establish whether any reflux observed was simply due to SPJ incompetence of true or due popliteal vein incompetence. A Valsalva manoeuvre was performed to assess venous valve competence as well as a manual compression—release test (femoral vein—compression below the knee; popliteal vein—above the ankle). No compression cuffs were used. Investigations were performed by experienced staff who routinely performed such examinations. Measurements were obtained using the pulsed Doppler mode of the ultrasound machines function and duration of reflux was measured directly from the trace with the assistance of the machine's software. Assessment of reflux was repeated several times at each site and an average value for reflux time was calculated. The leg compression-release test was used to assess the reflux time. We found that this technique resulted in good repeatability of measurements. We considered that a reflux time of $>0.5$ s is abnormal but included only patients with and RT of $>1.5$ s reflecting definite pathological reflux.

Duplex ultrasonography was used to assess incompetent deep veins for evidence of previous venous thrombosis. The diagnosis of secondary venous insufficiency was based on appearances suggestive of post-thrombotic changes including incomplete recanalisation, vein wall thickening and fibrotic scars in the vein lumen combined with venous reflux. These patients were assigned to the CEAP secondary reflux category. Patents were assigned to the appropriate CEAP clinical stage by a surgeon experienced in the management of venous diseases.

The surgical approach taken was individually tailored to each patient. All patients underwent superficial venous surgery consisting of ligation of incompetent saphenofemoral and SPJs and stripping of incompetent saphenous trunks. Junction surgery included dissection and ligation of all tributaries. We used a Babcock vein stripper to remove saphenous trunks and removed varices by stab avulsion. In 21 cases of calf perforating vein incompetence—defined by reflux of more than 0.5 s detected by duplex ultrasonography—subfascial endoscopic perforating vein surgery (SEPS) was performed. The endoscope was inserted medially to the tibia and the subfascial space dissected during visual monitoring. This permitted access to perforating veins in the posterior and medial aspects of the calf. All perforators found at surgery were grasped with bipolar diathermy-connected forceps and then coagulated and divided in keeping with previously published techniques.[13,14] One to 5 perforating veins (average: 2.4) were divided. Lateral perforating veins were ligated though separate skin incisions (in four cases). Table 2 summarises the operations performed.

Surgery was performed under epidural anaesthesia. During the perioperative period patients were given low-dose low-molecular weight heparin to prevent DVT. This was discontinued on discharge from hospital. After surgery, patients wore graduated-compression stockings (1st or 2nd compression class) or applied a short-stretch elastic bandage for a period of 3–4 weeks. Thirty days after the operation patients returned for further investigation by duplex ultrasound and PPG.

### *Statistical analysis*

The data in figures and tables have been represented

by the mean and standard deviation for all parameters. The paired Student *t*-test has been used for significance testing in order to compare the before and after surgery measurements of venous reflux time and refill time.

## Results

We included 24 patients in this study from 150 originally considered for inclusion. The CEAP clinical classification shows that seven limbs belong to class 2, 2 limbs to class 3, 12 to class 4 and 5 are in each of class 5 and 6. In addition, the investigated group was divided according to the disease aetiology, namely 21 legs with primary and 11 legs with secondary CVI. The findings on duplex ultrasonography are summarised in Table 1. In the majority of limbs (femoral and popliteal incompetence was accompanied by great saphenous vein reflux. In a few (three limbs) small saphenous vein reflux was present combined with deep vein reflux. Femoral vein incompetence was found in 28 cases and popliteal vein incompetence in 26 cases. The operations performed are shown in Table 2. The majority of surgery was to the great saphenous vein in keeping with the distribution of venous reflux shown by duplex ultrasound. SEPS was added to varicose vein operations in 20 patients.

The results of PPG VRT examination performed with a below-knee tourniquet PPG for the entire tested before the operation and 30 days after surgery are presented in Fig. 1. There was a statistically significant improvement in refilling times in the whole group, which was greatest in the patients presenting with primary deep vein reflux. In those where post-thrombotic damage had been seen on ultrasonography the increase in refilling time did not reach statistical significance.

The results of duplex ultrasound measured RT in the femoral vein before and after operation in all groups of patients are shown in graphs on Fig. 2. A decrease of RT was found in the whole group but this was largely confined to those without evidence of post-thrombotic damage. Separate analysis of the patients with post-thrombotic deep vein reflux showed a statistically insignificant reduction in reflux time.

The results of RT in the popliteal vein are presented in the same manner in Fig. 3. The whole group showed an improvement in venous refilling time, but separate analysis of the patients with primary and secondary deep vein reflux showed that the reduction in RT did not reach statistical significance in patients with secondary deep vein reflux.

## Discussion

Our observation of reduced deep vein reflux following surgery to superficial veins has been reported

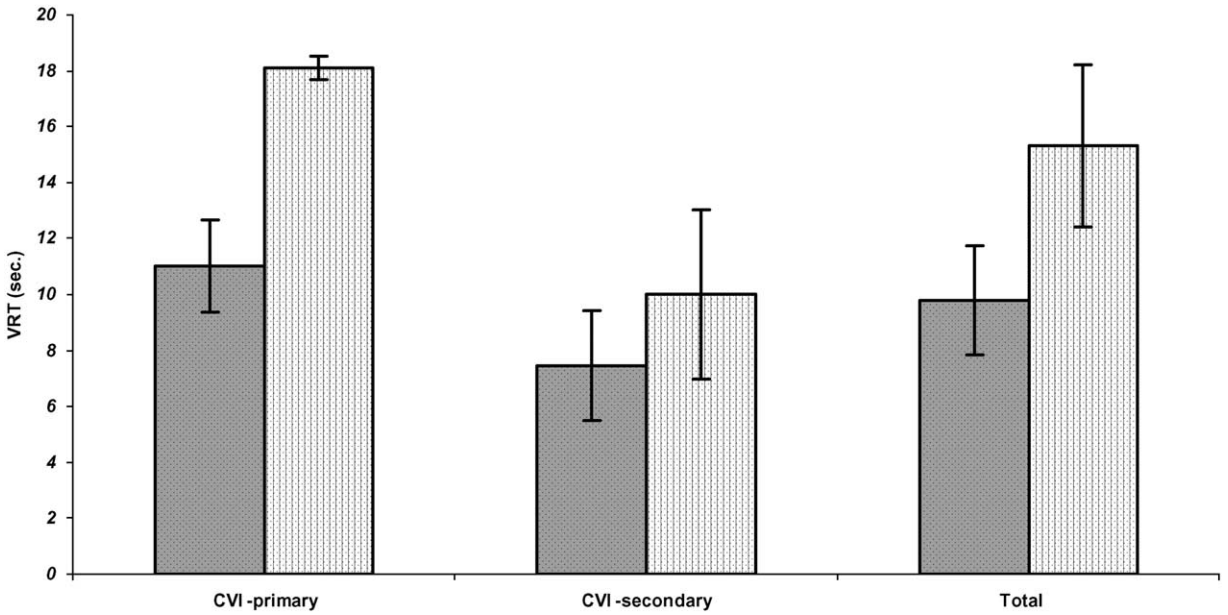


**Fig. 1.** Results of venous refill time (VRT) in PPG examinations before and after operation. Tests were performed with a below knee tourniquet; in primary CVI-improvement from 11 s (sd: 3.3) to 18 s (sd: 0.84), *t*-test $p < 0.001$; in secondary CVI-improvement from 7.5 s (3.9) to 10 s (sd: 6.0), *t*-test N.S.; in total group-improvement from 9.8 s (sd: 3.9) to 15 s (sd: 5.8), *t*-test $p < 0.001$.

**Table 1. Distribution of venous incompetence**

| Localization of reflux | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Deep veins | | Superficial veins | | | | | | |
| Femoral vein | Popliteal vein | Great saphenous vein above-knee | Great saphenous vein below-knee | Small saphenous vein | Non-saphenous veins | Perforating veins | No. of legs |
| + | + | + | + | + | − | + | 2 |
| + | + | + | + | − | − | + | 10 |
| + | + | + | − | − | − | − | 5 |
| + | + | + | − | − | − | + | 1 |
| + | + | + | − | + | − | + | 1 |
| + | + | − | − | − | − | − | 2 |
| + | + | − | − | − | + | + | 2 |
| + | + | − | − | − | + | − | 1 |
| + | − | − | − | − | − | + | 2 |
| + | − | + | − | − | − | + | 2 |
| − | + | + | − | − | − | − | 4 |

**Table 2. The types of operation performed**

| Type of operation | No |
|---|---|
| Long GSV* stripping | 9 |
| Long GSV stripping + SEPS** | 12 |
| Short GSV stripping | 0 |
| Short GSV stripping + SEPS | 3 |
| SSV*** stripping | 2 |
| SSV stripping + SEPS | 1 |
| GSV and SSV stripping | 0 |
| GSV and SSV stripping + SEPS | 2 |
| Excision of non-saphenous varices | 1 |
| Excision of non-saphenous varices + SEPS | 2 |

GSV* − , great saphenous vein; SEPS**, subfascial endoscopic perforator surgery; SSV***, small saphenous vein.

previously by other authors.[5–11] We aimed to select patients who had more severe venous disease than may have been the subject of earlier studies. We included patients who had a RT of more than 1.5 s and a VRT of less than 15 s. In general a RT 0.5 s is accepted as the limit for physiological reflux.[11,15] A few authors have accepted higher values, in the range 1 or 1.5 s as the upper limit of normal.[6,16,17] In cases where the RT exceeds a value of 0.5 s the clinical consequences of this may be trivial. Some authors suggest that symptomless reflux is a frequent occurrence, present in about 12% of patients.[18] Similar problems occur during the interpretation of plethysmography results. Published literature suggests a minimum VRT in normal subjects in the range 17–25 s. In clinically significant deep veins incompetence VRT measurements usually lie between 5 and 15 s.[19,20] To avoid any doubt about the significance of venous reflux in this study we have included only patients with a VRT of less than 15 s.

The results of surgery strongly depend on the aetiology of venous insufficiency.[21,22] In our opinion the only satisfactory way to confirm the presence of post-thrombotic changes in veins is by using imaging techniques. Some publications have relied on a medical history of DVT but this has been found to result in more than 20% of false positive and more than 60% false negative diagnoses.[23]

Our results confirm that deep vein reflux is reduced following superficial and perforating vein surgery but only inpatients with primary deep vein incompetence. The small improvement in patients with post-thrombotic veins did not reach statistical significance. A few authors who have studied this previously have reached similar conclusions.[8,10,24] However, in our study we deliberately selected patients with more severe venous deep vein reflux. Only Padberg has reported reduced deep venous reflux in patients with severe symptoms of venous insufficiency.[7]

Primary deep vein insufficiency in our patient

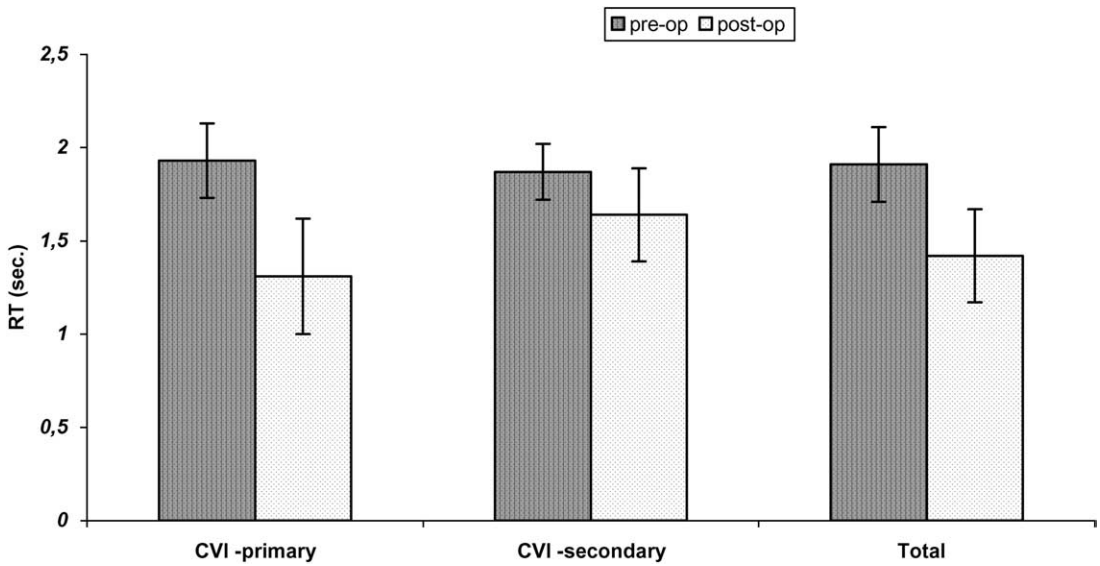


**Fig. 2.** Results of reflux time (RT) in the femoral vein measured by duplex ultrasound before and after operation; in primary CVI-improvement from 1.9 s (sd: 0.4) to 1.3 s (sd: 0.72), *t*-test $p < 0.001$; in secondary CVI-improvement from 1.9 s (sd: 0.3) to 1.6 s (sd: 0.5), *t*-test NS; in total group-improvement from 1.9 s (sd: 0.4) to 1.4 s (sd: 0.5), *t*-test $p < 0.001$.

group may be due to overload of the deep venous system by reflux of blood in the superficial veins, and hence is reversible after an surgery to abolish reflux in the superficial veins.[9–11] The inflow from the incompetent superficial veins leads to dilation and incompetence of the deep vein valves.[24] Jenneret *et al*. observed increased diameter and reflux of the common and superficial femoral veins in patients with varicose veins.[25] The result superficial venous surgery in patients with deep and superficial venous reflux appear to depend on whether or not deep vein reflux is due to post-thrombotic damage. If this can be established preoperatively then the outcome of treatment can be predicted.

It is also worth considering the importance of popliteal vein incompetence in relation to severity of the resulting CVI.[26–29] In our study, we found no difference in the results of haemodynamic tests of veins on the femoral and the popliteal veins.

Although a 'normal' value for PPG measured VRT is considered to be a value of greater than 20 s, few of our patients reached this level. In accordance with the generally accepted reporting standards a prolongation of the VRT by at least 5 s would be considered a success.[30] The VRT in our study group increased by an average of about 5.5 s following surgery.

Our assessments of duplex ultrasound measured reflux time showed return to 'normal' (< 0.5 s) in only

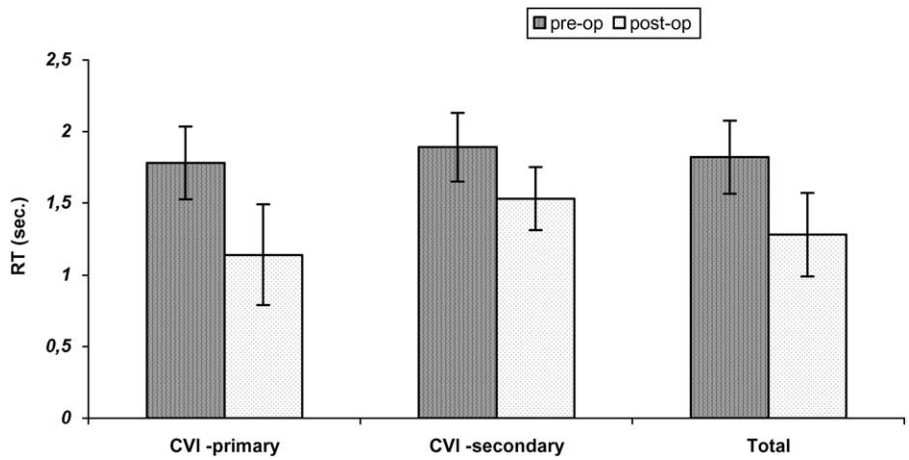


**Fig. 3.** Results of reflux time (RT) in the popliteal vein measured by duplex ultrasound before and after operation; in primary CVI-improvement from 1.7 s (sd: 0.51) to 1.1 s (sd: 0.61), *t*-test $p < 0.001$; in secondary CVI-improvement from 1.9 s (sd: 0.48) to 1.5 s (sd: 0.44), *t*-test NS; in total group-improvement from 1.8 s (sd: 0.51) to 1.3 s (sd: 0.58), *t*-test $p < 0.001$.

four cases, although there was an overall reduction in the average RT. This shows that our treatment strategy is far from perfect. Early intervention in patients with CVI may avoid permanent damage to the venous system and could improve the outcome of treatment results.[31] Since superficial and perforating vein surgery is straightforward this should be considered at an early stage in this group of patients with combined superficial and deep venous reflux. Our data confirm that a haemodynamic improvement can be achieved by this strategy, although little improvement was found in those with post-thrombotic deep vein damage.

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