

## Original Research Article

# Great saphenous vein diameter at different regions and its relation to reflux

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## ABSTRACT

**Background:** Great saphenous vein (GSV) incompetence is involved in the majority of cases of varicose disease. Standard pre-interventional assessment is required to decide the treatment modalities. GSV diameter measured at sapheno-femoral junction, proximal thigh, distal thigh, knee, proximal leg, distal leg. Analysis done to find at which diameter size the reflux expected to occur.

**Methods:** The study involved 100 limbs from outpatient vascular clinic. GSV diameter measurement was done at the sapheno-femoral junction, at the proximal thigh, at the distal thigh, below the knee, mid leg in correlation to the reflux.

**Results:** SFJ reflux (group I) was observed at  $7.16 \pm 2.30$  mm, proximal thigh (group II) at  $6.60 \pm 1.89$  mm, distal thigh (group III a) at  $6.12 \pm 1.63$  mm, knee (group III b) at  $5.78 \pm 1.60$  mm, proximal leg (group IV) at  $4.6 \pm 1.24$  mm, and mid leg (group V) at  $3.59 \pm 1.16$  mm.

**Conclusions:** Measurement at six sites revealed higher sensitivity and specificity to predict reflux, GSV diameter correlates with reflux, sites to predict reflux not only at SFJ and proximal thigh but GSV measurement at knee joint can predict reflux. Measurement of GSV at knee joint can predict reflux if more than 5.5 mm.

**Keywords:** Varicose veins, Great saphenous vein, Vein diameter at different regions, Comparison of clinical trials

## INTRODUCTION

Varicose disease affects one third of the population and has an impact on morbidity, quality of life and health costs. The great saphenous vein (GSV) is involved in the majority of cases.<sup>1</sup>

Symptoms include distressing feelings of swelling and heaviness and frank pain. Objective findings are meandering and dilated superficial veins, oedema, dermatitis, dermatosclerosis and skin ulceration. These manifestations are the consequence of long standing volume overload and hypertension in cutaneous veins caused by wall distension, valve incompetence, blood

flow abnormality and secondary phenomena such as allergy and inflammation.<sup>2</sup>

Treatment is directed towards abolition of venous reflux. For decades, this has been accomplished by ligation of the GSV at its junction with the common femoral vein (CFV) and vein stripping, first of the entire GSV, later limited to its refluxing part. In the last decades, alternative options became available, such as haemodynamic surgery, Endovenous thermal ablation and foam sclerotherapy.<sup>3-7</sup>

Duplex ultrasound is widely employed to guide these interventions. Comparison of treatment modalities

requires exact documentation of the clinical, anatomical and functional situation prior to whichever treatment is given.<sup>8</sup>

GSV diameters have been assessed at various sites with different techniques: upright or recumbent patient position, cross sectional or longitudinal imaging, and various sites of interest.<sup>2</sup>

A consensus-based manual recommends two sites where GSV diameters should be measured, 3 cm below the sapheno-femoral junction (SFJ) and mid-thigh, while earlier studies used a site 15 cm below the SFJ. Thus far, neither the clinical relevance of these measurements nor the relative significance of the site of measurement has been clarified. In this thesis, investigation done to find a possible correlation of GSV diameters measured at different regions and their relation to the reflux.<sup>8,9</sup>

Various investigations have been carried out to establish the duration of reflux standing which correlates with venous disease.<sup>10-12</sup>

Although the cut-off value was set at 0.5 s, a definition of reflux set at 1 s may avoid diagnosing pathology at borderline values when there are no clinical signs. Reflux duration decreases with severity of disease and has been described as the time taken for the anti-gravitational mechanisms of the leg to fail.<sup>12</sup>

### ***Venous arterial flow index***

The first non-invasive option for a quantitative measurement of haemodynamic parameters is duplex ultrasound. This can measure the velocity of blood flow in a vein. This parameter can be used to calculate the volume flow (l/min) by multiplying the average blood flow velocity (cm/s) by the cross-sectional area of the vein.<sup>13</sup>

The common femoral vein can be taken as a representative vessel from which the volume flow can be measured. Volume flow can also be measured in the saphenous vein.<sup>14</sup>

The diameters of the common femoral artery and common femoral vein are then measured in transverse view. Volume flow is measured in longitudinal view.

**Artery:** It is recommended to measure the flow over several pulses to calculate the time-averaged mean velocity (TAMV). This function is usually configured in the machine.

**Vein:** The typical flow pattern is slow and relatively constant, modulated by respiration. It should be measured over several seconds and then the average calculated as with the artery.

Since the artery and the vein flow in opposite directions, the flow in the vein appears as a negative value. It must be treated as positive for calculating the Venous arterial flow index (VAFI). The flow velocity is given in m/s, m/min or cm/s, at the site of the measured vessel diameter (d). The volume flow (VF) in each vessel is calculated from the diameters and flow velocities using the following formula:

$$VF [cm^3/s] = TAMV [cm/s] \times \Pi \times d^2/4 [cm^2].$$

$$1 \text{ cm}^3 = 1 \text{ ml area is } \Pi \times r^2 \text{ or } \Pi \times d^2/4.$$

If the volume flow in the common femoral vein and common femoral artery are designated VFv and VFa, respectively, then

$$VAFI = VFv [ml/min] / VFa [ml/min]$$

In subjects with healthy veins, the VAFI is  $\leq 1.0$ . In patients with haemodynamically significant impairment, the VAFI increases  $> 1.2$ . It can even increase up to 2.0. This means that the flow in the femoral vein is much higher than the arterial inflow into the leg. This occurs when there is a recirculation loop. The influence of intervention on haemo-dynamics is seen after only a few days when the high preoperative values return to normal.<sup>15</sup>

### ***Validation of the VAFI***

The index was measured in patients with different venous diseases under different conditions. It was shown that with primary varicose veins, significantly higher values were measured than those found in healthy subjects. A similar pattern was found in patients with post-thrombotic syndrome compared to healthy subjects and that the level of the VAFI values correlated with the clinical severity of the disease. In the above studies, subjects with healthy veins were found to have an average VAFI  $\leq 1.0$ . This may be interpreted to mean that there is a point of equivalence between arterial inflow per unit of time and the corresponding venous outflow per unit of time. The high VAFI values found in varicose patients may be an index of recirculation which normalises after intervention. With respect to the reliability of the measurement results, it was shown that the VAFI remained stable both during uninterrupted examination for 1 hr and over 3 consecutive days. The VAFI is a repeatable, sensitive parameter for venous haemodynamics which has been confirmed with modern phase-contrast MR techniques.<sup>15,16</sup>

The great saphenous vein at the proximal thigh was more uniform, easier to measure and more representative as a single measurement point. The average diameter in subjects with healthy veins was 7.5 mm ( $\pm 1.8$ ) at the sapheno-femoral junction and 3.7 mm ( $\pm 0.9$ ) in the proximal thigh. In subjects with reflux, the average diameter was 10.9 mm ( $\pm 3.9$ ) at the sapheno-femoral

junction and 6.3 mm ( $\pm 1.9$ ) in the proximal thigh. The diameter did not correlate with the Hach class.<sup>2</sup>

The objective of the study was to investigate a possible correlation of GSV diameters measured at sapheno-femoral junction, proximal thigh, distal thigh, below knee and at mid leg and their relation to the reflux.

## METHODS

It was a practitioner initiated prospective study performed in a vein clinic in Cairo and Menoufia from January 2018 to January 2019. Survey of the GSV was undertaken in consecutive outpatients who consulted with the suspicion or presence of a primary venous disorder 100 limbs included.

The protocol was accepted by the Ethics Committee of the Menoufia University, Egypt.

### Inclusion criteria

Patients aged with 18-60 years, primary varicose vein, eligible legs were included irrespective of the findings on the other leg were included in this study.

### Exclusion criteria

Patients with secondary varicose vein, recurrent varicose vein, deep venous reflux, acute disorders (thrombosis/phlebitis/cellulitis), lymphedema, pregnancy, age below 18 years and above 60 years were excluded.

### Assessment

History taking will involve previous DVT, surgery, any comorbidity, clinical examination general and local including clinical, etiologic, anatomic and pathophysiologic (CEAP) classification, duplex u/s.

Examination involves History taking and clinical examination both general and local,

All clinical findings were documented. Protocol examination of varicose vein was done with duplex ultrasound (standing position).

### Superficial system

SFJ, GSV reflux, vein diameter: transverse, SFJ distal to terminal valve (2 cm), proximal thigh (15 cm after SFJ), distal thigh (just above medial trochanter 2 cm), below the knee (proximal leg) (below medial trochanter 2 cm), mid leg (below medial trochanter 10 cm), anterior accessory saphenous vein, posterior accessory saphenous vein, sapheno-popliteal junction, small saphenous vein.

### Deep system

Inferior vena cava (IVC), common iliac vein (CIV) and external iliac vein (EIV), common femoral vein, Femoral

vein (FV) and deep femoral vein, popliteal vein, posterior tibial vein (PTV) and anterior tibial vein (ATV).

Duplex ultrasound examinations were performed by a single investigator with a Toshiba Apolio 400 colour-coded duplex scanner fitted with a 7.5-MHz linear probe and 2-5 MHz curved probe.<sup>17,18</sup>

### Steps of examination

*Asses patency and competency:* case examination of lower limb venous system during standing and supine position (Figure 1).



**Figure 1: Case examination of lower limb venous system during standing and supine position: (a) GSV at knee region reflux; (b) GSV at knee region diameter.**

*Standing position:* SSV, intersaphenous V, PASV, SPJ, Calf v, GSV (SFJ, proximal thigh, distal thigh, knee, proximal leg, distal leg), AASV, SASV.

*Lying position:* CFV, SFJ, FV, DEEP FV, POP V, PTV, ATV, EIV, CIV and CIV diameter, IVC.

The GSV was examined in the standing position applying toe movements, manual compression and decompression as well as Valsalva maneuver to assess orthograde flow

and reflux. Reflux lasting longer than 1 s was considered pathologic.<sup>19</sup>

Patients were classified into 5 groups: Group I: SFJ reflux, Group II: proximal thigh GSV reflux (15 cm after SFJ), Group III: A: distal thigh (just above medial trochanter 2 cm), Group III: B: knee GSV reflux, Group IV: below knee GSV reflux (proximal leg) (below medial trochanter 2 cm), Group V: mid leg GSV reflux (below medial trochanter 10 cm).

No assessment was made of dilated distal branch veins and eventually incompetent perforator veins. Excluded lower limbs with reflux through the AASV, PASV and SSV. Trunkal GSV was examined only.

Clinical findings were documented according to the highest CEAP class. Legs range from teleangiectasies (C1) to active venous ulcers (C6).

In all cases, the aetiology was primary (Ep) and pathophysiology reflux (Pr). The anatomy was varicose GSV trunk with or without branch varices.

Vein diameters were measured holding the probe transversely with no pressure. Duplicate measurements were taken at five sites: at the SFJ distal to the terminal

valve and 15 cm below the junction. This site, chosen by CHIVA (conservative ambulatory haemodynamic management of varicose veins) group members, shows parallel walls of the GSV and is located above the junction of the most proximal branch veins). At the knee, at the proximal leg and mid leg.<sup>20,21</sup>

### Statistical analysis

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when their distribution found parametric and median with inter-quartile range (IQR) when their distribution found non parametric. Also qualitative variables were presented as number and percentages, the comparison between two independent groups with quantitative data and parametric distribution were done by using independent t-test. Receiver operating characteristic curve was used in the quantitative form to determine the best cut of point, area under curve, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), the confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p value was considered significant as the following:  $p > 0.05$ : non-significant,  $p < 0.05$ : significant,  $p < 0.01$ : highly significant.

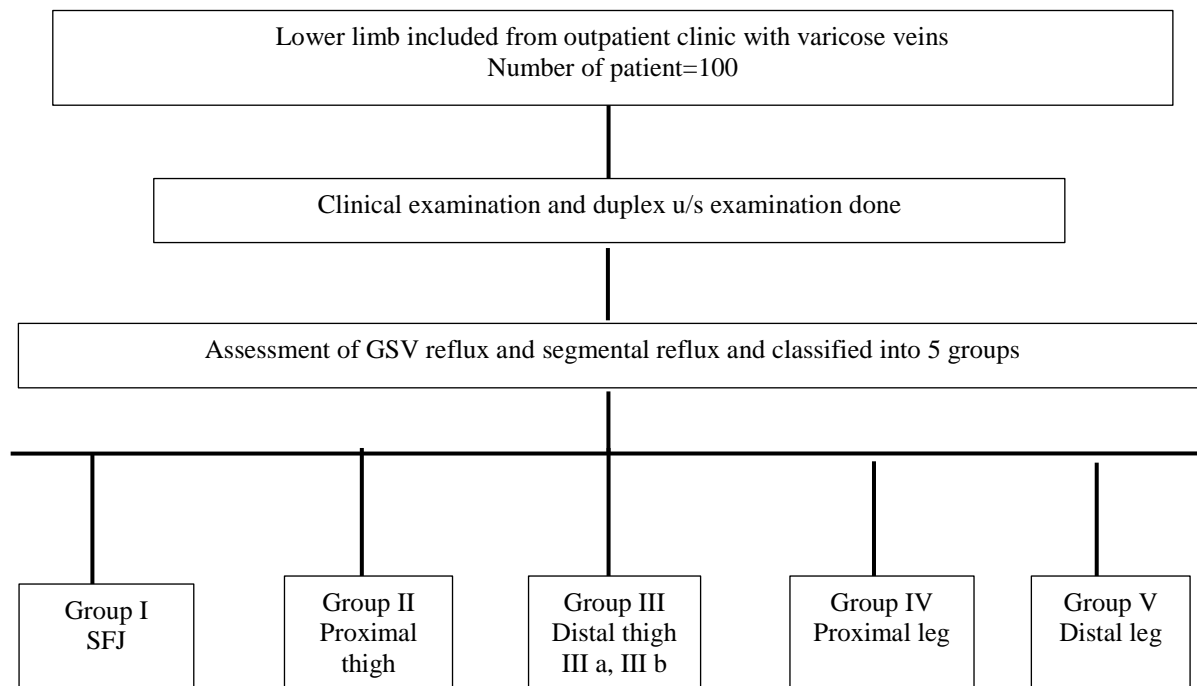


Figure 2: Study flow chart.

## RESULTS

Patients were randomized 100 lower limbs included with trunkal GSV reflux or segmental reflux. Table 1 presents

the demography of patients of 100 limbs. The mean of age the participants was  $35.74 \pm 7.76$  years (range: 18-52). Female preponderance was seen (70.0%). Mean weight of the patients was  $91.78 \pm 16.39$  (range: 50-130).

**Table 1: Demography of the patients.**

<b>Age in years (mean±SD)</b>	35.74±7.76
Range	18-52
<b>Gender</b>	
Male	30%
Female	70%
<b>Weight (mean±SD)</b>	91.78±16.39
Range	50-130

Clinical findings of a venous disorder were teleangiectases (C1) found in 34%, branch varices (C2) in

32%, oedema (C3) in 42%, dermatosclerosis (C4) in 18% and active venous ulcer (C6) in 6%.

In patients with SFJ reflux (group I), reflux occur at 7.16±2.30 mm (Table 2). In patients with proximal thigh reflux (group II), reflux occur at 6.60±1.89 mm (Table 3). In patients with distal thigh reflux (group III a), reflux occur at 6.12±1.63 mm (Table 4). In patients with knee reflux (group III b), reflux occur at 5.78±1.60 mm (Table 5). In patients with proximal leg (group IV), reflux occur at 4.6±1.24 mm (Table 6). In patients with mid leg reflux (group V), reflux occur at 3.59±1.16 mm (Table 7).

**Table 2: SFJ diameter size screening.**

SFJ	Not reflux N=46	Reflux N=54	Test value*	P value	Sig.
<b>Mean±SD</b>	5.66±1.59 mm	7.16±2.30 mm	-3.743	<0.001	HS
<b>Range</b>	3.50-9.50	4.00-14.00			

P>0.05: Non significant (NS); p<0.05: Significant (S); p<0.01: highly significant (HS) •: Independent t-test.

**Table 3: GSV proximal thigh size screening.**

GSV proximal thigh	Not reflux N=42	Reflux N=58	Test value*	P value	Sig.
<b>Mean±SD</b>	4.38±0.93	6.60±1.89	-7.031	<0.001	HS
<b>Range</b>	2.40-6.00	3.60-11.00			

P>0.05: Non significant (NS); p<0.05: Significant (S); p<0.01: highly significant (HS) •: Independent t-test.

**Table 4: GSV distal thigh size screening.**

GSV Distal thigh	Not reflux N=40	Reflux N=60	Test value*	P value	Sig.
<b>Mean±SD</b>	4.19±1.04	6.12±1.63	-6.619	<0.001	HS
<b>Range</b>	2.50-6.50	3.10-9.50			

P>0.05: Non significant (NS); p<0.05: Significant (S); p<0.01: highly significant (HS) •: Independent t-test.

**Table 5: GSV knee region size screening.**

GSV knee	Not reflux N=40	Reflux N=60	Test value*	P value	Sig.
<b>Mean±SD</b>	3.66±0.82	5.78±1.60	-7.711	<0.001	HS
<b>Range</b>	2.30-5.50	3.60-11.00			

P>0.05: Non significant (NS); p<0.05: Significant (S); p<0.01: highly significant (HS) •: Independent t-test.

**Table 6: GSV proximal leg size screening.**

GSV proximal leg	Not reflux N=40	Reflux N=60	Test value*	P value	Sig.
<b>Mean±SD</b>	3.09±0.74	4.60±1.24	-6.933	<0.001	HS
<b>Range</b>	2.00-4.80	2.80-7.50			

P>0.05: Non significant (NS); p<0.05: Significant (S); p<0.01: highly significant (HS) •: Independent t-test.

**Table 7: GSV mid leg size screening.**

GSV mid leg	Not reflux N=68	Reflux N=32	Test value*	P value	Sig.
<b>Mean±SD</b>	2.56±0.46	3.59±1.16	-6.396	<0.001	HS
<b>Range</b>	1.50-3.80	1.90-6.00			

P>0.05: Non significant (NS); p<0.05: Significant (S); p<0.01: highly significant (HS) •: Independent t-test.



Vein diameters were larger in the presence of reflux, compared with its absence, GSV diameters were assessed with regard to their value to predict reflux.

Sensitivity and specificity are calculated for thresholds at the mean points. The cut of point at SFJ was  $>5.7$  mm with sensitivity 77.7%. Cut of point at proximal thigh was at  $>7$  mm with sensitivity 44.4%. Cut of point at distal thigh was  $>5.5$  mm with sensitivity 60%. Cut of point at knee was  $>4.2$  mm with sensitivity 86.6%. The cut of point at proximal leg was  $>3.5$  mm with sensitivity 73%. Cut of point at distal leg  $>3$  mm with sensitivity 56%.

Measurement at six sites revealed higher sensitivity and specificity to predict reflux.

## DISCUSSION

Comparison of treatment modalities requires exact documentation of the clinical, anatomical and functional situation in each patient using standardised and validated techniques. However, even the recommendations of the Union Internationale de Phlébologie (UIP) regarding measurement of GSV diameter at different sites lack proper validation.<sup>17</sup>

Diameter measurement at the PT seems to have some advantages as compared with measurement at the SFJ, which is a landmark easily identified with ultrasound. While GSV reflux in the groin is readily identified measurement of vein diameter right there is challenging for several reasons.<sup>22</sup>

The curvature of the inguinal GSV renders adjustment of the ultrasound probe exactly perpendicular to the vein axis difficult. Further, the shape of the vein is influenced by joining epigastric, pudendal and accessory veins and eventual aneurysmatic dilatations caused by deep venous refluxes. Thus, diameter assessment in the groin appears less reliable.<sup>22</sup>

The proximal thigh site 15 cm below the SFJ is located in the truncal portion of GSV where the vein is cylindrical and largely devoid of joining branches. The site is also well accessible and diameter measurements can be taken reliably.<sup>22</sup>

The CHIVA group measures diameters 15 cm distal to the SFJ because the PT site allows outcome assessment, as their treatment strategy leaves the GSV trunk in situ even when crossectomy is performed.<sup>9,20,21</sup>

Data revealed a debatable finding: GSV diameter, venous haemodynamics (refilling times in photoplethysmography) and clinical disease class did not differ whether reflux was above knee only or above and below knee. The finding is in disagreement with the understanding

that the length of reflux in the GSV would have an influence on disease severity.<sup>23-25</sup>

The correlation between the two measurement sites permitted calculation of a conversion factor used to review selected publications. It disclosed a wide range of diameters in patients worked up for interventions with different techniques (Table 8).

The data suggest that some studies included patients with minor disease. The same may be true for a recent study that found no correlation between GSV diameter and quality of life. The reported diameters were within the limits of the control subjects of this study.<sup>26</sup>

Diameter assessment at the PT seems suitable for stratification of patients allocated to future interventional trials as well as for outcome evaluation. With more data available it may also become an argument in the discussion of treatment options with patients, which is not the case at the moment.<sup>2</sup>

The study adds sites to predict reflux not only at SFJ and Proximal thigh but GSV measurement at knee joint can predict reflux.

In the previous study by Mendoza et al, measurements were taken at the SFJ as proposed by the UIP and compared it with measurements at the PT as used and published by the CHIVA group because no data on the mid-thigh point have been published until 2010.<sup>2</sup> Measurement at the PT as compared to measurement at the SFJ demonstrated higher accuracy and both higher sensitivity and specificity for venous disease class as well as for prediction of reflux. Thus, diameter measurement at the PT may develop as a surrogate parameter for specific clinical situations.<sup>2</sup>

The findings of his study included 182 legs, 60 had no GSV reflux (controls; group I), 51 had above-knee GSV reflux only (group II) and 71 had GSV reflux above and below knee (group III). GSV diameters in group I measured 7.5 mm ( $\pm 1.8$ ) at the SFJ and 3.7 mm ( $\pm 0.9$ ) at the PT. In groups II and III, they measured 10.9 mm ( $\pm 3.9$ ) at the SFJ and 6.3 mm ( $\pm 1.9$ ) at the PT ( $p < 0.001$  each).<sup>2</sup> Measurement at the PT revealed higher sensitivity and specificity to predict reflux and clinical class.<sup>2</sup> The observation of his study concluded that GSV diameter correlates with clinical class, measurement at the PT being more sensitive and more specific than measurement at the SFJ.<sup>2</sup>

In the present study patients were classified into 5 groups. Classified reflux according to the site of measurement, number of patients 100, results were nearly equal as introduced by Mendoza et al at SFJ and proximal thigh, Measurement of GSV at knee joint can predict reflux if  $>5.5$  mm.<sup>2</sup>

**Table 8: Literature derived pre interventional GSV diameters measured at one of the sites studied in this survey and converted to the other site; data are sorted according to diameter size.<sup>2</sup>**

Author treatment investigated (group)	Year	Number	Site of measurement	SFJ diameter (in mm)	Proximal thigh diameter (in mm)
Pittaluga, (ASVAL)	2009	303	SFJ	7.1±0.2	4.0±0.4
Gonzalez-Zeh, (Foam)	2008	53	SFJ	7.6±3.0	4.3±1.7
Theivacoumar, (LASER)	2008	84	SFJ	7.7±2.0	4.4±1.1
Theivacoumar, (LASER)	2008	27	SFJ	7.9±1.6	4.5±0.9
Gonzalez-Zeh, (LASER)	2008	45	SFJ	8.2±3.2	4.6±1.8
Pittaluga, (HLS)	2009	270	SFJ	8.4±0.3	4.8±0.5
Creton, (ClosureFast)	2010	295	SFJ	8.4±2.3	4.8±1.3
Pannier, (LASER)	2010	85	SFJ	10.0±0.4	5.7±0.2
This study	2010	122	SFJ and proximal thigh	10.9±3.9	6.3±1.9
Parés (Stripping)	2010	167	Proximal thigh	11.5±1.1	6.5±1.9
Cappelli, (CHIVA)	2000	177	Proximal thigh	11.7±1.0	6.7±1.7
Doganci, (LASER)	2010	54	SFJ	11.8±4.1	6.7±7.3
Parés, (CHIVA)	2010	167	Proximal thigh	12.0±1.1	6.8±2.0
Doganci, (LASER)	2010	52	SFJ	12.1±4.3	6.8±7.6
Cappelli, (CHIVA)	2000	77	Proximal thigh	12.4±1.1	7.1±2.0

### Limitation of study

Duplex is operator dependent to avoid this conflict one operator do all cases, number of patients were 100 only, study target only patients came to vein clinic, no relation found between quality of life and diameter.

### CONCLUSION

Measurement at six sites revealed higher sensitivity and specificity to predict reflux, GSV diameter correlates with reflux, Sites to predict reflux not only at SFJ and Proximal thigh but GSV measurement at knee joint can predict reflux. Measurement of GSV at knee joint can predict reflux if more than 5.5 mm.

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