# A comparison of below-knee vs above-knee endovenous ablation of varicose veins

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## ABSTRACT

**Objective:** Varicose veins have a significant impact on quality of life and can commonly occur in the thigh and calves. However, there has been no large-scale investigation examining the relationship between anatomic distribution and outcomes after varicose vein treatment. This study sought to compare below-the-knee (BTK) and above-the-knee (ATK) varicose vein treatment outcomes.

**Methods:** Employing the Vascular Quality Initiative Varicose Vein Registry, 13,731 patients undergoing varicose vein ablation for either BTK or ATK lesions were identified. Outcomes were assessed using patient-reported outcomes (PROs) and the Venous Clinical Severity Score (VCSS). Continuous variables were compared using the *t*-test, and categorical variables were analyzed using the $\chi^2$ test. Multivariable logistic regression was used to estimate the odds of improvement after intervention. The multivariable model controlled for age, gender, race, preoperative VCSS composite score, and history of deep vein thrombosis.

**Results:** Patients who received below-knee treatment had a lower preoperative VCSS composite (7.0 ± 3.3 vs 7.7 ± 3.3; $P <$ .001) and lower PROs composite scores (11.1 ± 6.4 vs 13.0 ± 6.6; $P <$ .001) compared with those of patients receiving above-knee treatment. However, on follow-up, patients receiving below-knee intervention had a higher postoperative VCSS composite score (4.4 ± 3.3 vs 3.9 ± 3.5; $P <$ .001) and PROs composite score (6.1 ± 4.4 vs 5.8 ± 4.5; $P =$ .007), the latter approaching statistical significance. Patients receiving above-knee interventions also demonstrated more improvement in both composite VCSS (3.8 ± 4.0 vs 2.9 ± 3.7; $P <$ .001) and PROs (7.1 ± 6.8 vs 4.8 ± 6.6; $P <$ .001). Multivariable logistic regression analysis similarly revealed that patients receiving above-knee treatment had significantly higher odds of improvement in VCSS composite in both the unadjusted (odds ratio [OR], 1.45; 95% confidence interval [CI], 1.28-1.65; $P <$ .001 and adjusted (OR, 1.31; 95% CI, 1.14-1.50; $P <$ .001) models. Patients receiving above-knee treatment also had a significantly higher odds of reporting improvement in PROs composite in both the unadjusted (OR, 1.85; 95% CI, 1.64-2.11; $P <$ .001) and adjusted (OR, 1.65; 95% CI, 1.45-1.88; $P <$ .001) models.

**Conclusions:** Treatment region has a significant association with PROs and VCSS composite scores after varicose vein interventions. Preoperatively, there were significant differences in the composite scores of VCSS and PROs with patients receiving BTK treatment exhibiting less severe symptoms. Yet, the association appeared to reverse postoperatively, with those receiving BTK treatments exhibiting worse PROs, worse VCSS composites scores, and less improvement in VCSS composite scores. Therefore, BTK interventions pose a unique challenge compared with ATK interventions in ensuring commensurate clinical improvement after treatment. (J Vasc Surg Venous Lymphat Disord 2024;12:101679.)

**Keywords:** Chronic venous disease; Treatment region; Varicose veins; Vascular Quality Initiative

Varicose veins are present in 10% to 30% of the population or 22 million women and 11 million men, with higher rates among the elderly.[1,2] Twice as common in women than men, venous varicosities can arise due to genetic predisposition, weakened vascular walls, incompetent valves, and increased vascular pressure.[3] Varicosities can lead to significant symptoms and morbidity such as swelling, pain, lipodermatosclerosis, inflammation, superficial thrombophlebitis, infection, and ulceration. Ulceration is particularly challenging to treat, sometimes lasting long periods and recalcitrant to multiple treatments.[3] Following failure of conservative management

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that may include external compression, exercise, reduction in prolonged standing, and leg elevation, invasive interventions such as endovenous thermal ablation, sclerotherapy, saphenous ligation and stripping are performed, with excellent overall outcomes and generally minor complications associated with these procedures.[3,4] Patients can present with varicose veins in the thigh or in the calf. Reports in literature show that below-the-knee (BTK) varicosities constitute the majority of cases, whereas above-the-knee (ATK) varicosities make up less than 20% of cases.[5] ATK cases more commonly involve incompetent veins, but resolution of varicose veins following radiofrequency or laser ablation is higher in ATK compared with BTK cases.[5-7] However, many studies that investigated outcomes in varicosities following treatment did not stratify patients receiving treatment above or below the knee.

Although there has been some investigation comparing varicose veins BTK vs ATK, there is a paucity of research comprehensively comparing ATK vs BTK varicose vein treatment outcomes. Here we investigate if there are differences in preoperative and postoperative patient-reported outcomes (PROs) and Venous Clinical Severity Score (VCSS). Using the Vascular Quality Initiative (VQI) Varicose Vein Registry (VVR), our aim was to compare pre- and postoperative VCSS and PROs among BTK vs ATK groups. Based on the literature, we hypothesize that ATK cases will present more severely preoperatively, but BTK will have worse outcomes postoperatively than ATK after adjusting for clinically significant baseline characteristics.

## ARTICLE HIGHLIGHTS

- **Type of Research**: Retrospective review of the prospectively collected data of the Vascular Quality Initiative Varicose Vein Registry
- **Key Findings:** Compared with patients who received below-knee treatment, those who received above-knee treatment had higher preoperative Venous Clinical Severity Score (VCSS) composite (7.7 ± 3.3 vs 7.0 ± 3.3; $P < .001$) and higher patient-reported outcomes (PROs) composite scores (13.0 ± 6.6 vs 11.1 ± 6.4; $P < .001$). On follow-up, patients receiving above-knee intervention had a lower postoperative VCSS composite (3.9 ± 3.5 vs 4.4 ± 3.3; $P < .001$) and PROs composite scores (5.8 ± 4.5 vs 6.1 ± 4.4; $P = .007$), the latter nearing statistical significance. Patients receiving above-knee interventions also demonstrated more improvement in both composite VCSS (3.8 ± 4.0 vs 2.9 ± 3.7; $P < .001$) and PROs (7.1 ± 6.8 vs 4.8 ± 6.6; $P < .001$). Multivariable logistic regression analysis similarly revealed that patients receiving above-knee treatment had significantly higher odds of improvement in VCSS composite (odds ratio, 1.31; 95% confidence interval, 1.14-1.50; $P < .001$). Patients receiving above-knee treatment also had a significantly higher odds of reporting improvement in PROs composite (odds ratio, 1.65; 95% confidence interval, 1.45-1.88; $P < .001$).
- **Take Home Message:** Treatment region has a significant association with patient-reported outcomes and VCSS composite scores after varicose vein interventions. Preoperatively, patients receiving above-knee interventions exhibited more severe symptoms as measured by VCSS and PROs. However, on follow-up after treatment, patients treated below-the-knee exhibited higher postoperative composite VCSS and PROs scores. Patients receiving above-knee treatment had higher odds of demonstrating improvement in VCSS and PROs than those treated below-the-knee.

## METHODS

The VQI is the official quality improvement registry of the Society for Vascular Surgery (SVS). The VVR prospectively collects all varicose vein procedures performed at participating centers, including those performed at office-based practices, ambulatory, inpatient, and vein centers. It is overseen by the SVS Patient Safety Organization (SVS PSO) in collaboration with the American Venous Forum (AVF). Access to the VQI VVR was granted through a national application process and approved by the SVS PSO National Research Advisory Committee (RAC) (Proposal #4584). Data in the VQI VVR files from January 2015 to December 2020 were analyzed. Because this was a retrospective review of deidentified preoperative, procedural, and follow-up data, the present study was deemed exempt from informed consent by the Mount Sinai Health System Institutional Review Board (STUDY-22-01,660).

**Case identification and classification.** From 2015 to 2020, all patients receiving varicose vein interventions were identified. Procedures occurring before 2015 were excluded as they were entered into VQI VVR retrospectively, and those entered after 2020 were excluded to ensure adequate time for follow-up. Patients who received concurrent phlebectomy and prior ablations, including prior thermal, laser, mechanochemical, chemical, embolic adhesive, surgery, high ligation and stripping, stripping, stab phlebectomy, trivex phlebectomy, open ligation, and endoscopic ligation were excluded. Those with indicated location crossing both the thigh and calf, such as the great saphenous vein of the thigh and calf, as well as any patients receiving ablation of the anterior accessory great saphenous vein (AASV) of the calf were excluded. The remaining 13,731 patients were then stratified by the treatment region: above-knee and below-knee.

**Patient characteristics and clinical outcomes.** The characteristics of patients treated in the two treatment regions were separately compared with respect to demographics and comorbidities, namely age, gender, race/ethnicity, prior deep vein thrombosis (DVT), number of veins treated, performance site, Clinical-Etiology-Anatomy-Pathophysiology (CEAP) class, treatment type, anatomy, insurer, perioperative anticoagulation, prior pulmonary embolism, VCSS components (pain, pigmentation, varicose veins, edema, inflammation, induration, ulceration duration, ulcer diameter, ulcer number, compression therapy), PRO components (heaviness, achiness, swelling, throbbing, itching, appearance, work impact), composite VCSS, composite PROs, and rate of deep reflux. Clinical outcomes included improvement in VCSS components, improvement in VCSS and PRO composites, improvement in PRO components, and rate of systemic and leg complications. Improvement was calculated as the preprocedural VCSS score minus the postprocedural VCSS score.

**Statistical analysis.** The Student *t*-test was used to determine whether there were statistically significant differences by treatment region for preoperative and postoperative VCSS and PROs composite scores, improvement in VCSS and PROs composite scores, and for individual components of each scoring system. Demographic, perioperative, and comorbidity comparisons were also conducted stratified by treatment region. These univariate analyses were conducted to compare results with those of the confounder-adjusted analyses. Categorical variables are represented using frequency counts with percentages, whereas continuous variables are reported as mean ± standard deviation or median with interquartile range (IQR). Univariate differences among categorical variables were analyzed using the $\chi^2$ test, and continuous variables were analyzed using two-tailed independent sample *t*-tests. The Wilcoxon rank sum test was used to analyze a location shift in the medians between the two groups.

The primary endpoint was the VCSS composite, and the secondary endpoint was the PROs composite. A logistic regression model was used to assess the unadjusted and adjusted odds ratios (ORs) for improvement in VCSS composite and PROs composite. The multivariable model adjusted for potential clinically significant confounders including age, gender, race, preoperative VCSS composite score, and history of DVT. Improvement in VCSS composite in these models was defined as improvement in VCSS composite >0, whereas no improvement was defined as VCSS composite ≤0. Dichotomizing improvement in VCSS composite allows for a direct assessment of whether patients improved clinically after the intervention. Likewise, improvement in PROs composite was defined as improvement in composite PROs >0, whereas no improvement was defined as composite PROs ≤0. A type I error of 0.05 was maintained in the setting of 24 multiple comparisons by employing a Bonferroni correction to give a significance criterion of 0.002. A sample size calculation was conducted. In prior work, a difference of 16.3% in complete varicose vein resolution was found between patients who received above-knee (41.9%) compared with below-knee (25.6%) intervention for varicose veins.[5] Based on a power of 90% and a significance level of 0.002, a sample size of 2882 was determined through a power analysis for a two-sample, two-sided *t*-test. This sample size was necessary to detect clinically meaningful differences. Thus, the VQI VVR registry was well positioned to answer the clinical questions posed in the present study. All statistical analyses were performed using R version 3.6.2 (R Core Team).

## RESULTS

Between January 1, 2015, and December 31, 2020, 6882 patients with below-knee and 6849 patients with above-knee treatment for varicose veins were identified. Compared with patients undergoing ATK treatment, those undergoing BTK treatment were older (59.5 ± 12.4 vs 56.9 ± 12.9 years; $P < .001$) and had fewer veins treated (median, 1; IQR, 1-2 for BTK; median, 1; IQR, 1-3; $P < .001$) (Table I). Patients receiving below-knee treatment had a lower proportion with prior DVT (5.3% vs 6.7%; $P = .001$), deep reflux (12.0% vs 18.1%; $P < .001$), and prior pulmonary embolism (1.0% vs 4.7%; $P < .001$) (Table I). A higher proportion of patients receiving BTK intervention were performed in the office setting (95.0% vs 90.9%; $P = .001$), covered by Medicare (33.6% vs 21.7%; $P < .001$), and were placed on no perioperative anticoagulation (96.3% vs 93.3%; $P < .001$) (Table I). Those receiving below-knee treatment had a lower preoperative VCSS composite and a lower PROs composite score compared with those of patients receiving above-knee treatment (Table I). There was no statistically significant difference in average follow-up time between the below-knee (164 ± 154 days) and above-knee (171 ± 164 days) groups ($P = .011$).

On follow-up, patients receiving BTK intervention had a higher postoperative VCSS composite score (4.4 ± 3.3 vs 3.9 ± 3.5; $P < .001$) and PROs composite score (6.1 ± 4.4 vs 5.8 ± 4.5; $P = .007$), the latter nearing statistical significance. Similarly, patients receiving below-knee interventions also exhibited less improvement in both composite VCSS (2.9 ± 3.7 vs 3.8 ± 4.0; $P < .001$) and composite PROs (4.8 ± 6.6 vs 7.1 ± 6.8; $P < .001$) (Table II). There were no statistically significant differences in rates of systemic ($P = .113$) or leg ($P = .470$) complications on follow-up. Compared with patients receiving below-knee treatment, patients receiving above-knee treatment had a significantly higher odds of exhibiting improvement in VCSS composite in both the unadjusted (Table III) and adjusted (OR, 1.31; 95% confidence interval [CI], 1.14-1.50;

**Table I.** Comparison of demographics, comorbidities, and perioperative details of patients undergoing above-knee and below-knee treatment for varicose veins

| Variable | | Below-knee (n = 6882) | Above-knee (n = 6849) | *P* value |
|---|---|---|---|---|
| Age, years | | 59.46 ± 12.37 | 56.88 ± 12.88 | <.001 |
| Female | | 70.8 (4872) | 70.8 (4852) | .965 |
| White | | 87.6 (6026) | 86.3 (5908) | .025 |
| Prior DVT | | 5.3 (364) | 6.7 (456) | .001 |
| Number of veins treated | | 1 [1-2] | 1 [1-3] | <.001 |
| Performance site | Ambulatory | 23 (1.6) | 34 (3.1) | .001 |
| | Inpatient | 0 (0.0) | 1 (0.1) | |
| | Office | 1350 (95.0) | 994 (90.9) | |
| | Outpatient | 48 (3.4) | 64 (5.9) | |
| CEAP class | C0-C2 | 2246 (32.9) | 2321 (34.3) | <.001 |
| | C3 | 2069 (30.3) | 2224 (32.9) | |
| | C4 | 2032 (29.7) | 1714 (25.3) | |
| | C5 | 211 (3.1) | 188 (2.8) | |
| | C6 | 276 (4.0) | 316 (4.7) | |
| Treatment type | Thermal laser | 1436 (20.9) | 2368 (34.6) | <.001 |
| | Thermal radiofrequency | 1821 (26.5) | 2235 (32.6) | |
| | Surgery | 202 (2.9) | 380 (5.5) | |
| | Other | 3423 (49.7) | 1866 (27.2) | |
| Truncal anatomy | AASV thigh | 0 (0.0) | 2430 (35.5) | |
| | GSV calf | 4036 (58.6) | 0 (0.0) | |
| | GSV thigh | 0 (0.0) | 4068 (59.4) | |
| | SAGSV thigh | 0 (0.0) | 245 (3.6) | |
| | SSV calf | 2846 (41.4) | 0 (0.0) | |
| | SSV thigh extension | 0 (0.0) | 106 (1.5) | |
| Insurer | Commercial | 4044 (58.8) | 4820 (70.4) | <.001 |
| | Medicaid | 418 (6.1) | 384 (5.6) | |
| | Medicare | 2314 (33.6) | 1483 (21.7) | |
| | Medicare Advantage | 24 (0.3) | 34 (0.5) | |
| | Military/Veterans Administration | 35 (0.5) | 20 (0.3) | |
| | Non-United States insurance | 0 (0.0) | 3 (0.0) | |
| | Self-pay | 47 (0.7) | 105 (1.5) | |
| Perioperative anticoagulation | None | 6628 (96.3) | 6382 (93.3) | <.001 |
| | LMWH | 68 (1.0) | 206 (3.0) | |
| | UFH | 145 (2.1) | 192 (2.8) | |
| Prior pulmonary embolism | 1.0% (14) | 4.7% (51) | <0.001 | |
| Preoperative VCSS composite | | 7.02 ± 3.29 | 7.66 ± 3.32 | <.001 |
| Preoperative PROs composite | | 11.12 ± 6.37) | 13.04 ± 6.57 | <.001 |
| Preoperative VCSS components | | | | |
| Pain | None | 881 (13.0) | 355 (5.3) | <.001 |
| | Mild | 3463 (51.1) | 2952 (44.0) | |
| | Moderate | 1917 (28.3) | 2506 (37.3) | |
| | Severe | 520 (7.7) | 901 (13.4) | |
| Varicose veins | None | 107 (1.6) | 97 (1.4) | <.001 |
| | Mild | 2535 (37.4) | 1638 (24.4) | |
| | Moderate | 3063 (45.2) | 3237 (48.2) | |
| | Severe | 1075 (15.9) | 1741 (25.9) | |
| Pigmentation | None | 4730 (69.4) | 4716 (69.9) | .002 |

**Table I.** Continued.

| Variable | | Below-knee (n = 6882) | Above-knee (n = 6849) | *P* value |
|---|---|---|---|---|
| | Mild | 1311 (19.2) | 1178 (17.5) | |
| | Moderate | 651 (9.6) | 749 (11.1) | |
| | Severe | 120 (1.8) | 102 (1.5) | |
| Venous edema | None | 2862 (42.1) | 2894 (43.1) | <.001 |
| | Mild | 2471 (36.4) | 2201 (32.7) | |
| | Moderate | 1186 (17.5) | 1144 (17.0) | |
| | Severe | 274 (4.0) | 483 (7.2) | |
| Inflammation | None | 6040 (89.1) | 5761 (85.9) | <.001 |
| | Mild | 517 (7.6) | 665 (9.9) | |
| | Moderate | 188 (2.8) | 224 (3.3) | |
| | Severe | 35 (0.5) | 60 (0.9) | |
| Induration | None | 6058 (89.4) | 5985 (89.2) | .643 |
| | Mild | 506 (7.5) | 497 (7.4) | |
| | Moderate | 172 (2.5) | 173 (2.6) | |
| | Severe | 42 (0.6) | 54 (0.8) | |
| Ulcer duration | None | 6560 (96.1) | 6475 (95.8) | .394 |
| | <3 months | 120 (1.8) | 112 (1.7) | |
| | 3 to 12 months | 98 (1.4) | 120 (1.8) | |
| | >12 months | 47 (0.7) | 52 (0.8) | |
| Ulcer diameter | 0 cm | 6567 (96.2) | 6474 (95.8) | .056 |
| | <2 cm | 137 (2.0) | 128 (1.9) | |
| | 2-6 cm | 83 (1.2) | 88 (1.3) | |
| | >6 cm | 40 (0.6) | 67 (1.0) | |
| Ulcer number | 0 | 6561 (96.1) | 6465 (95.7) | .034 |
| | 1 | 197 (2.9) | 242 (3.6) | |
| | 2 | 26 (0.4) | 22 (0.3) | |
| | ≥3 | 46 (0.7) | 30 (0.4) | |
| Compression therapy | No | 499 (7.4) | 558 (8.3) | <.001 |
| | Intermittent | 703 (10.4) | 934 (13.9) | |
| | Most days | 2446 (36.1) | 1801 (26.8) | |
| | Everyday | 3132 (46.2) | 3427 (51.0) | |
| Preoperative PRO components | | | | |
| Heaviness | | 1.70±1.34 | 2.08±1.40 | <.001 |
| Achiness | | 1.94±1.28 | 2.25±1.32 | <.001 |
| Swelling | | 1.76±1.46 | 1.97±1.55 | <.001 |
| Throbbing | | 1.19±1.29 | 1.45±1.46 | <.001 |
| Itching | | 1.05±1.28 | 1.21±1.37 | <.001 |
| Appearance | | 2.06±1.06 | 2.38±1.09 | <.001 |
| Work impact | | 1.43±1.19 | 1.70±1.26 | <.001 |

AASV, Anterior accessory saphenous vein; *DVT*, deep vein thrombosis; *CEAP*, Clinical-Etiology-Anatomy-Pathophysiology; *GSV*, great saphenous vein; *PRO*, patient-related outcomes; *VCSS*, Venous Clinical Severity Score.
Data are presented as number (%), median [interquartile range], or mean ± standard deviation.

*P* < .001) models. Patients receiving above-knee treatment also had a significantly higher odds of reporting improvement in PROs composite in both the unadjusted (Table III) and adjusted (OR, 1.65; 95% CI, 1.45-1.88; *P* < .001) models.

## DISCUSSION

There is a paucity of literature stratifying patients by location of varicosities. Previous studies in this area have included all patients presenting with varicosities, including those presenting for reinterventions. However,

**Table II.** Unadjusted comparison of postoperative outcomes of patients undergoing above-knee and below-knee treatment for varicose veins

| Variable | | Below-knee (n = 6882) | Above-knee (n = 6849) | *P* value |
|---|---|---|---|---|
| CEAP class | C0-C2 | 51.0 (1645) | 63.8 (2038) | <.001 |
| | C3 | 15.7 (508) | 14.5 (464) | |
| | C4 | 25.6 (827) | 16.0 (512) | |
| | C5 | 5.3 (172) | 3.5 (113) | |
| | C6 | 2.3 (74) | 2.2 (69) | |
| Postoperative VCSS composite | | 4.43 ± 3.32 | 3.92 ± 3.51 | <.001 |
| Postoperative PROs composite | | 6.13 ± 4.40 | 5.82 ± 4.52 | .007 |
| Improvement in VCSS composite | | 2.85 ± 3.72 | 3.78 ± 3.97 | <.001 |
| Improvement in PROs composite | | 4.80 ± 6.56 | 7.12 ± 6.76 | <.001 |
| Improvement in VCSS components | | | | |
| Pain | | 0.93 ± 0.97 | 1.24 ± 1.03 | <.001 |
| Pigmentation | | 0.11 ± 0.32 | 0.09 ± 0.28 | <.001 |
| Varicose veins | | 1.02 ± 1.12 | 1.37 ± 1.12 | <.001 |
| Venous edema | | 0.54 ± 0.86 | 0.58 ± 0.93 | .031 |
| Inflammation | | 0.10 ± 0.41 | 0.14 ± 0.48 | <.001 |
| Induration | | 0.09 ± 0.42 | 0.08 ± 0.39 | .206 |
| Ulcer duration | | 0.04 ± 0.35 | 0.03 ± 0.30 | .252 |
| Ulcer diameter | | 0.04 ± 0.30 | 0.04 ± 0.31 | .794 |
| Ulcer number | | 0.04 ± 0.29 | 0.03 ± 0.21 | .063 |
| Compression therapy | | 0.42 ± 1.22 | 0.69 ± 1.27 | <.001 |
| Improvement in PROs components | | | | |
| Heaviness | | 0.84 ± 1.57 | 1.42 ± 1.63 | <.001 |
| Achiness | | 0.95 ± 1.56 | 1.47 ± 1.60 | <.001 |
| Swelling | | 0.85 ± 1.66 | 1.17 ± 1.66 | <.001 |
| Throbbing | | 0.73 ± 1.33 | 1.00 ± 1.50 | <.001 |
| Itching | | 0.59 ± 1.25 | 0.82 ± 1.36 | <.001 |
| Appearance | | 0.74 ± 1.28 | 1.16 ± 1.32 | <.001 |
| Work impact | | 0.84 ± 1.31 | 1.21 ± 1.41 | <.001 |
| Complications | | | | |
| Systemic | | 0.1 (6) | 0.2 (14) | .113 |
| Leg | | 3.4 (233) | 3.2 (216) | .470 |

*CEAP*, Clinical-Etiology-Anatomy-Pathophysiology; *PRO*, Patient-related outcomes; *VCSS*, Venous Clinical Severity Score.
Data are presented as number (%) or mean ± standard deviation.

we excluded patients with prior ablations and concurrent phlebectomy, focusing on patients at initial presentation, and our prevalence of BTK cases matched the ATK prevalence, even though BTK is significantly more prevalent in the population and other studies.[5] In light of previous studies showing that patients with ATK varicosities experienced higher rates of complete resolution but also presented with more incompetent veins, we hypothesized that ATK cases will present more severely preoperatively, whereas BTK will have worse outcomes postoperatively.[5,7]

Preoperatively, ATK treatment had worse symptoms as measured by PROs and exhibited more severe disease as measured by VCSS. Postoperatively, this association appeared to reverse, with patients receiving BTK treatments exhibiting worse PROs, VCSS composite scores, and less improvement in VCSS composite scores. Prior literature yielded similar results: one study examined ATK (19.4% of cases) and BTK (75.7% of cases) varicosities

**Table III.** Unadjusted and adjusted odds ratios (*ORs*) for improvement in composite Venous Clinical Severity Score (*VCSS*) and composite patient-reported outcomes (*PROs*)

| Above-knee vs below-knee | OR | *P* value | 95% CI |
|---|---|---|---|
| Improvement in VCSS composite | | | |
| Unadjusted model | 1.45 | <.001 | 1.28-1.65 |
| Adjusted model | 1.31 | <.001 | 1.14-1.50 |
| Improvement in PROs composite | | | |
| Unadjusted model | 1.85 | <.001 | 1.64-2.11 |
| Adjusted model | 1.65 | <.001 | 1.45-1.88 |

*CI*, Confidence interval.

and found that complete resolution was 41.9% in ATK locations and 25.6% in BTK lesions.[5] Notably, this previous study used complete disease resolution as an outcome, whereas we measured PROs and VCSS.

Several characteristics of ATK varicosities may lead to a more severe preoperative presentation. ATK veins are generally longer and larger, require blood to travel farther against gravity, are subject to greater hydrostatic pressure as the veins travel proximally, may have fewer valves, and withstand greater weight-bearing forces as the upper leg supports the weight of the torso. These factors lead to increased pressure, venous damage, decreased blood flow, stasis, and reflux, exacerbating severity at presentation. Venous perforators between the superficial and deep venous systems are larger and more numerous in ATK veins, contributing to increased hydrostatic pressure. Additionally, it has long been observed that BTK varicosities are more prevalent on initial presentation and can advance to ATK, suggesting that ATK varicosities represent more severe disease progression.[8] Epidemiological differences such as obesity, pregnancy, and decreased activity level may be associated with ATK varicosities. Given that there are strong genetic risk factors for varicose vein development, patients who are genetically predisposed may also be more likely to develop the more severe ATK varicosities.[9]

The improved treatment response in ATK cases compared with BTK cases, measured as improved PROs and VCSS composite scores, is likely multifactorial. Because ATK cases present more severely at baseline with greater hydrostatic pressure, reflux, and incompetence, they may experience greater pressure relief, greater blood flow restoration, greater room for clinical improvement, and a stronger treatment response. The larger ATK varicosities and vessel diameters may contribute to the stronger treatment response compared with BTK cases with more challenging endovascular access. The larger muscles of the thigh may more effectively improve blood flow from the ATK-treated veins. BTK cases may present later due to a slower, more insidious disease progression, allowing varicosities to progress for a longer period of time before intervention and causing a lead-time bias and worse BTK treatment response, whereas ATK cases may present earlier in the disease course due to the severity of their symptoms and rapid disease progression, resulting in better postoperative outcomes. Below-knee varicosities may sometimes go untreated because of the risk of nerve injury, leading to diminished clinical improvement postoperatively compared with that of above-knee varicosities. BTK interventions pose unique challenges compared with ATK interventions in ensuring commensurate clinical improvement after treatment.

Additional studies are needed to compare ATK vs BTK cases to further investigate varicose vein presentation characteristics, nuances of treatment response, genetic predisposition, patient characteristics such as activity level, body mass index, pregnancy, age, and occupation, physiological and anatomical differences, challenges of surgical access, and lead-time before presentation.

**Study Limitations.** This study is a retrospective review of the prospectively collected VVR of the VQI. Limitations include subjectivity among subjects in reporting PROs, differences between clinicians in assessing VCSS clinical scores, coding and collection errors in the VQI registry, and 81.9% follow-up. In addition, classification was simplified to patients receiving ATK vs BTK treatment, but the treatment access site may not always correlate with the location of the varicose vein, and complex, advanced varicosities can cross the knee joint. Additionally, whether below-knee patients had a prior above-knee intervention or vice versa was not possible to determine using the present clinical registry. Finally, the study may be subject to operator bias given the absence of randomization, selection bias against patients who were not candidates for treatment, and residual confounding from an unaccounted prior varicosity treatment in a different anatomical region.

## CONCLUSIONS

Treatment region appears to have a significant association with PROs and VCSS composite scores after varicose vein interventions. Preoperatively, those receiving above-knee treatment had higher preoperative composite VCSS scores and composite PROs scores. Above-knee treatment exhibited worse symptoms and more severe disease than those receiving below-knee treatment. However, the association appeared to reverse postoperatively with those receiving below-knee treatments exhibiting worse PROs, worse VCSS composites scores, and less improvement in both VCSS and PROs composites. Therefore, below-knee interventions pose a unique challenge compared with above-knee interventions in ensuring commensurate clinical improvement after treatment.

## AUTHOR CONTRIBUTIONS

Conception and design: HB, WT
Analysis and interpretation: HB, VG, JS, PK, FA, US, EF, COC, AO, WT
Data collection: AO
Writing the article: HB, VG, WT
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Final approval of the article: HB, VG, JS, PK, FA, US, EF, COC, AO, WT
Statistical analysis: HB, JS, WT
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## DISCLOSURES

None.

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