Fascial relationships of the short saphenous vein

Alberto Caggiati, MD, PhD, *Rome, Italy*

Objectives: **The purpose of this study was to define the relationships between the short saphenous vein (SSV) and the fasciae of the leg, including the muscular fascia (MF) and the membranous layer (ML) of the subcutaneous tissue.**
Methods: **Fascial relationships of the SSV were evaluated by means of dissection in 30 cadaveric limbs and by means of duplex sonography in 270 healthy limbs from living subjects.**
Results: **All along the leg, the SSV courses in a flat compartment delimited by the MF and the ML. Neither results from dissection nor results from sonographic examination demonstrated piercing of the MF by the SSV. A hyperechoic lamina similar to a ligament connects the SSV to the fasciae by which it is encased. An SSV tributary and collateral vessels course out of this space and are devoid of any fascial wrapping.**
Conclusions: **The SSV does not correspond to the classical description of a "superficial" vein. In fact, from the anatomical point of view, the SSV is an interfascial vein, because it is encased by two connective fasciae, just like the greater saphenous vein. Fascial relationships of the SSV suggest that muscular contraction potentially influences the caliber and hemodynamics of the SSV. In addition, the ML is arranged as a sort of mechanical shield that could counteract dilative pathologic conditions in varicose limbs. (J Vasc Surg 2001;34:241-6.)**

Knowledge of the complex anatomy of the short saphenous vein (SSV) is essential to improve the results of surgery for varicose veins.[1] One of the more complex topics about the SSV anatomy is its relationships to the surrounding fasciae, which are the subject of controversy in both the anatomical and surgical literature.[2-15]

According to the anatomical literature, because the SSV is a superficial vein, it should course within the subcutaneous tissue: "The superficial veins are immediately under the skin, in the superficial fascia."[2] In contrast to this, however, most anatomical and surgical textbooks state that the upper segment of the SSV is subfascial because it perforates the muscular fascia (MF) at the lower margin of the gastrocnemius muscle[2,3] or at a variable distance from the popliteal fold.[4-10] Other authors have reported that at the upper leg the SSV courses in a duplication of the MF and not below it.[11-15]

For clarification of the SSV's planar anatomy, its relationships with the fasciae of the leg were reevaluated by correlating anatomical and clinical techniques of investigation. Results of traditional dissection and stereomicroscopy of serial cross-sectioned specimens in cadaveric limbs were correlated with ultrasonography evaluations performed in healthy volunteers. Particular attention was given to identification of the membranous layer (ML) of the subcutaneous tissue and to differentiation of the ML from the MF. The ML consists of a connective lamina that separates the subcutaneous tissue in a deep and a superficial fatty layer.[16] The ML is evident in many areas of the human body (eg, along the course of the greater saphenous vein [GSV]).[17,18] In all other areas, however, the ML is not distinguishable from the underlying MF to which it adheres.

From the Department of Anatomy, University "La Sapienza," Rome, Italy.
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Reprint requests: Alberto Caggiati, MD, PhD, Department of Anatomy, University "La Sapienza," Via A. Borelli 50, I-00161, Rome, Italy (e-mail: alberto.caggiati@uniroma1.it).

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MATERIALS AND METHODS

Anatomical investigations. Twenty-two limbs from fresh or fixed cadavers (5 men, 6 women; mean age, 67 years) underwent planar dissection of the posterior leg and thigh. Cadavers were selected from those currently used in the Department of Anatomy for didactic purposes. Corpses showing vascular, muscular, or skeletal diseases were excluded. Vein health was evaluated anatomically in cadaveric limbs. Fat lobules were gently removed with low-vacuum aspiration (model M15; Mefor Ltd, Rome, Italy) or thin forceps to preserve the complex three-dimensional arrangement of the subcutaneous connective framework.[17] A total of 112 cross-sectioned specimens (10-15 mm in thickness) were serially removed from eight inferior extremities of four fixed cadavers (2 women, 2 men; mean age, 72 years) and observed under a Zeiss stereomicroscope Stemi 2000C (Zeiss, Jena, Germany).

Ultrasonography. Ultrasonography evaluation of the SSV anatomy was performed in 135 volunteers (78 women, 57 men; mean age, 44 years) in whom results of clinical and instrumental examinations excluded the presence of vascular disease (CEAP classification: 0). The anatomy of the SSV and of its main tributary vessels was evaluated with the patient in a standing position from the ankle to the posterior thigh with high-frequency (7.5-10 MHz) linear probes. Duplex sonography was also performed in all veins to assess continence. Reflux was tested by manual distal compression of the limb with subsequent sudden release. A vein was considered incompetent when retrograde flow lasted 0.5 seconds.

RESULTS

All along the leg, the SSV coursed between the MF and the ML. No SSV was shown to pierce the MF.

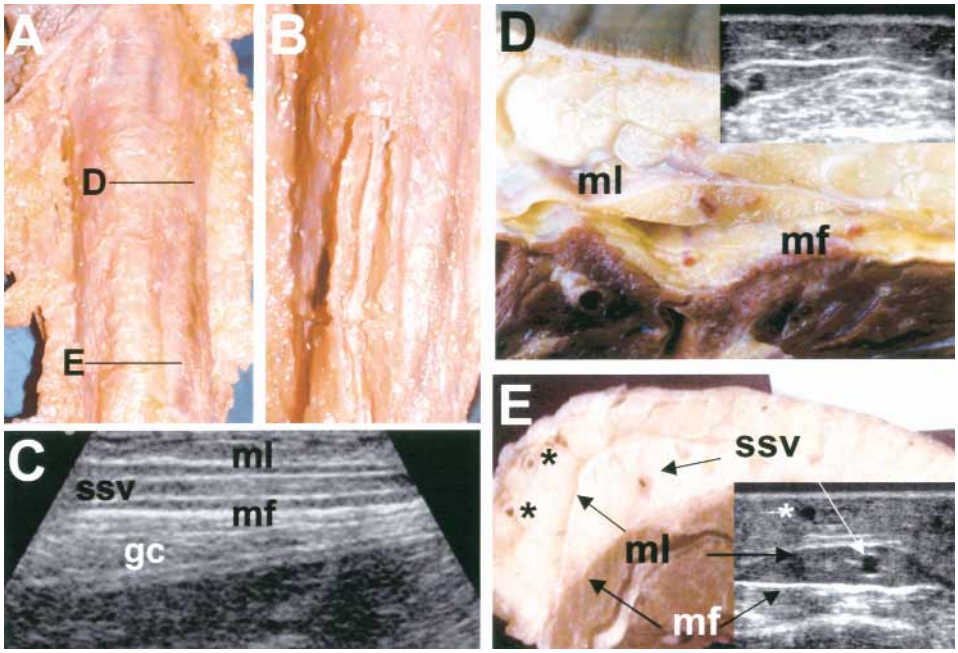

Fig 1. A, Posterior face of leg after removal of superficial layer of fat. At lower leg (*E-line*), compartment of SSV appears as a hemicylindrical prominence along Achilles tendon. At upper leg (*D-line*), compartment of SSV does not extend past convex margin of gastrocnemius muscle. *Lines D* and *E* indicate where sections shown in **D** and **E** have been removed. **B,** SSV is evident only after dissection of the ML. **C,** Longitudinal ultrasonography scanning of lower margin of the gastrocnemius muscle (*gc*). SSV courses parallel to membranous layer (*ml*) and muscular fascia (*mf*). The latter is not pierced by the vein. **D,** Transverse section of posterior leg at level of the gastrocnemius muscle (corresponding to *D-line* traced in **A**). Membranous layer (*ml*) is easily distinguishable from underlying muscular fascia (*mf*). *Insert:* The corresponding ultrasonography feature. **E,** Transverse section of leg swollen because of lipedema (corresponding to *E-line* traced in **A**). A greater amount of fat spreads SSV from its fascial wrapping. *Insert:* The corresponding ultrasonography pattern. Note presence of large collateral veins (*asterisk*) in a more superficial plane of subcutaneous tissue.

The fasciae of the leg and the compartment of the SSV

The ML of the posterior leg could be appreciated in anatomical preparations after a gentle planar dissection of the subcutaneous fat (Fig 1, *A* and *B*). Under the stereomicroscope (Fig 1, *D* and *E*), this fibroelastic lamina appeared as a white-yellowish membrane formed by the interlacing of the connective sheets of the hypodermis. Because of its hyperechogenicity, the ML was easily recognizable on ultrasonography and appeared as sharply demarcated from the surrounding hypoechoic fat tissue (Fig 1, *C*; *D,* insert; *E,* insert). Ultrasonography identification of the ML was occasionally difficult when hypodermic fat was scarce, as in slender legs and at the ankle.

Along the path of the SSV, the ML arched over the vein to join the MF laterally and medially with respect to the vessel, delimiting a narrow fatty space (Fig 2, *A* and *C*). In healthy legs this compartment was so narrow (1-2 mm) that the SSV was closely encased by the two fasciae (Fig 2, *B* and *D*). Conversely, in legs that were swollen because of lipedema, the compartment of the SSV appeared enlarged up to 6 to 8 mm, and the greater amount of fat spread the SSV from its fascial wrapping (Fig 1, *E*, insert). The compartment delimited by the MF and the ML was continuous from the posterior leg to the popliteal fossa. Over the SSV, this compartment contained the superficial sural artery, the sural nerve, and the terminal portion of the SSV tributaries.

At the ankle, the ML bridged from the synovial sheaths of the peroneal muscles to the calcaneal tendon (Fig 3). More cranially, the compartment delimited by the MF and ML was visible along the midline of the posterior leg and showed a semilunar aspect because of the convexity of the calcaneal tendon (Fig 2, *C* and *D*). At the upper leg, where the SSV coursed in the groove between the two bellies of the gastrocnemius muscle (Figs 1, *D,* and 2, *A* and *B*), the compartment of the SSV demonstrated a rhomboid profile (Fig 2, *B*). The ML overlying the SSV appeared thickened, forming the roof of the muscular groove (Fig 2, *A*). Nevertheless, it was easily distinguishable from the underlying MF (Fig 1, *D*).

At the lower margin of the popliteal fossa, the MF disappeared from below the SSV to follow the diverging heads of the gastrocnemius muscle bellies, whereas the ML bridged the popliteal fossa to reach the posterior thigh (Fig 4). The ML was extremely thickened at this level and, thus, was the main component of the popliteal fascia. The

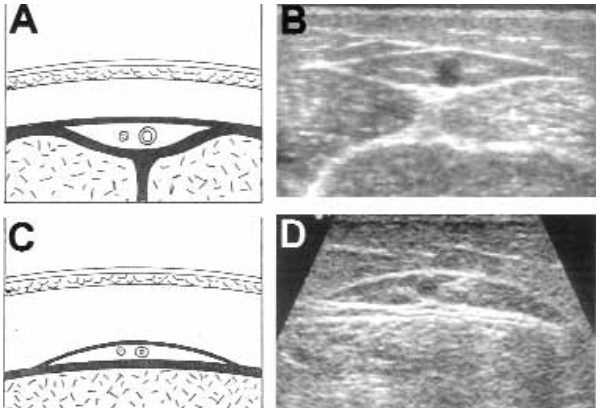

Fig 2. A, At upper leg, MF (*thick black line*) lines the groove between two heads of the gastrocnemius muscle. ML (*thin black line*) does not extend past convex margin of the gastrocnemius muscle. **B,** Corresponding ultrasonography pattern. Note two hyperechoic laminae connected to SSV adventitia. **C,** At lower leg, compartment of SSV shows semilunar profile because it extends past convex margin of Achilles tendon. **D,** Corresponding ultrasonography pattern.

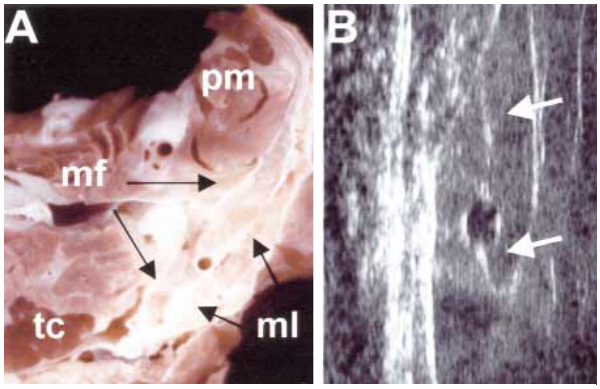

Fig 3. Fascial relationships of SSV at ankle. **A,** Cross-sectioned specimen showing SSV encased by muscular fascia (*mf*) and membranous layer (*ml*). *pm,* Peroneal muscles; *tc,* tendo calcaneus. **B,** Corresponding ultrasonography scan from a leg swollen because of lipedema. Note hyperechoic laminae of the "saphenous ligament" (*arrows*).

popliteal fascia appeared reinforced in its peripheral portions by fibers from the gastrocnemius, semitendinosus, and biceps femoris muscle envelopes.

At the popliteal fossa, the anatomy of the SSV varied according to its different patterns of termination (Fig 4):

Group A. In 186 limbs (62%) the SSV ended at the popliteal fossa in the popliteal vein or in one of the gastrocnemius muscle veins. The terminal portion of the SSV became deep after the two heads of the gastrocnemius muscles diverged toward their femoral insertions. Consequently, the SSV did not pierce the fascial envelope. In three (1%) of these limbs, the popliteal segment of the SSV appeared drastically reduced in caliber (< 1 mm) after a large perforator, usually termed "May's" or "Gastrocnemius Point" perforating vein, connected the SSV to a gastrocnemius muscle vein at the upper leg.

Group B. In 42 limbs (14%), the SSV joined the deep stem more cranially, in one of the deep veins of the posterior thigh (deep femoral vein, superior articular vein, persistent ischiatic vein). The terminal portion of the SSV crossed the fat tissue of the popliteal fossa obliquely to course below the muscles of the posterior thigh (semitendinosus and long head of the biceps femoris) without piercing their fascia.

Group C. In 72 limbs (24%) the SSV did not end in the popliteal fossa. The SSV was continuous with an upward extension, the femoropopliteal vein. This vessel, which is also called "Giacomini's" vein,[19] coursed superficially in the fat tissue of the popliteal fossa to ascend for a variable length along the midline of the posterior thigh. Here the femoropopliteal vein coursed in the groove between the semitendinosus muscle and the long head of

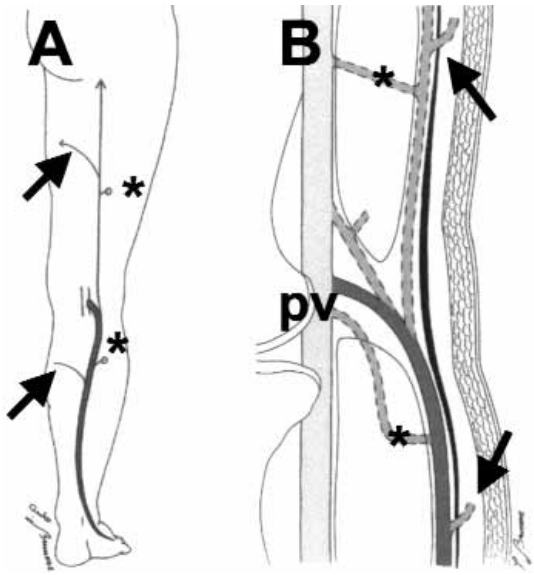

Fig 4. A, Schematic drawing representing course of SSV and femoropopliteal vein. Their main connections with perforators (*asterisk*) and with the GSV (*arrows*) are demonstrated. **B,** Schematic drawing representing different patterns of SSV termination. Perforating and connecting veins are highlighted as in **A**. *pv,* Popliteal vein.

the biceps femoris muscle and was covered by a membranous lamina. In 57 limbs (19%), an oblique vessel connected the femoropopliteal vein with the GSV. In 15 limbs (5%), the femoropopliteal vein drained into the deep stem of the posterior thigh through a perforator. In two limbs (0.6%), the femoropopliteal vein could be demonstrated

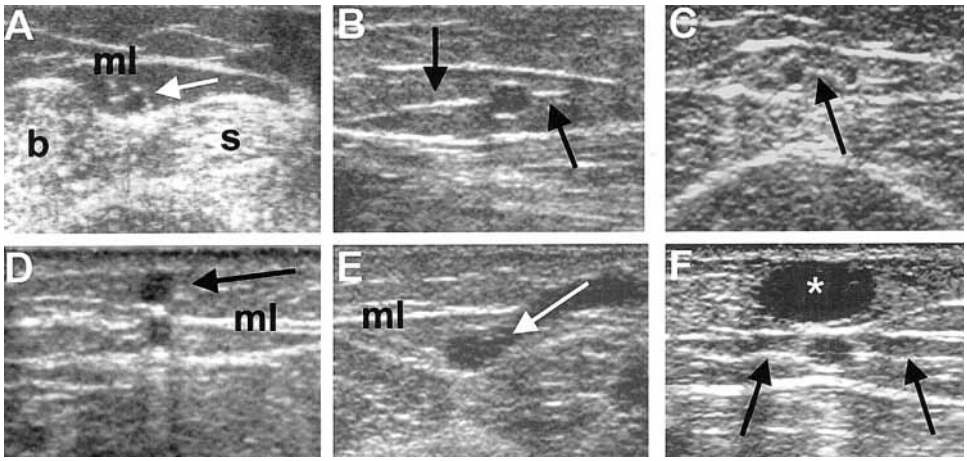

Fig 5. A, Transverse ultrasonography section of posterior thigh. Femoropopliteal vein (*arrow*) courses between envelopes of the biceps femoris (*b*) and semitendinosus (*s*) muscles and membranous layer (*ml*). **B,** Two hyperechoic laminae (*arrows*) connect adventitia of femoropopliteal vein to fasciae that line its compartment. **C,** Duplication of SSV. Note that two vessels are connected by hyperechoic lamina (*arrow*). **D,** "External accessory saphenous vein" (*arrow*) courses parallel to SSV, above membranous layer (*ml*). **E,** Only terminal segment of SSV tributary vein enters SSV compartment (*arrow*), piercing membranous layer (*ml*). **F,** Transverse ultrasonography scan of a limb excluded from anatomical evaluation because of presence of varicose veins in posterior leg. SSV shows a light dilatation and is overlaid by a greatly dilated external accessory saphenous vein (*asterisk*). Note hyperechoic laminae of the saphenous ligament (*arrows*).

all along the posterior face of the thigh up to the gluteal crease where it joined the inferior gluteal vein. The femoropopliteal vein could also be observed in 98 limbs from group A and in 25 from group B (global incidence 195/300 [65%]).

The different levels at which the SSV converged in the deep stem include the following: (1) below the popliteal fossa: 1% (in the gastrocnemius muscle vein); (2) at the popliteal fossa, below the popliteal fold: 7%; (3) at the popliteal fossa, below the popliteal fold: 54%; (4) above the upper margin of the popliteal fossa: 14% (into the femoral deep femoral, articular, or ischiatic veins); and (5) higher termination due to connection with the femoropopliteal vein: 24%.

Anchoring of the SSV

With transverse ultrasonography scanning, it was possible to observe two hyperechoic laminae connecting the adventitia of the SSV and the femoropopliteal vein to the fasciae by which they were encased (Figs 2, *B*; 3, *B*; 5, *B*). These laminae were easier to be demonstrated in the midtract of the SSV.

Duplication of the SSV

Partial duplication of the SSV was observed in 12 limbs (4%). The duplication was segmental and primarily involved the midportion of the SSV. The duplicated saphenous branches coursed within the compartment delimited by the ML and MF and were connected by a hyperechoic lamina (Fig 5, *C*).

Nerve relationships

Nerve relationships of the SSV could be evaluated only in dissected limbs. At the popliteal fossa, careful dissection demonstrated the relationships of the SSV with terminal twigs of the posterior cutaneous nerve of the thigh. These small twigs could be followed down along the SSV to communicate with the sural nerve, which merged from the muscular compartment approximately at midcalf. Distally, the sural nerve coursed deep in the subcutaneous tissue, below the ML. At the lower leg, the sural nerve was medial to the SSV in 19 limbs (63%) and lateral in 11 limbs (37).

SSV tributaries

Tributaries and connecting veins coursed more superficially from the fascial compartment of the SSV (Fig 5, *D*). They were close to the deep face of the dermis, devoid of any fascial wrapping, and surrounded by only loose adipose tissue. Only the terminal tract of these vessels entered within the compartment of the SSV piercing the ML immediately before convergence (Fig 5, *E*).

The number and path of the SSV tributaries varied so greatly that these data cannot be reported simply. However, it is important to point out the presence in 51 limbs (17%) of a macroscopic (1-2 mm) vein (Fig 5, *D*) that ascended parallel to the SSV in a more superficial plane of the hypodermis (just above the ML).

DISCUSSION

The SSV does not correspond to the classic anatomical depiction of a superficial vein[2] or to those depictions that

suggest that its upper segment should be subfascial.[3-10] Anatomically, the SSV is an "interfascial" vein as it courses in a compartment delimited by the MF and the ML, exactly like the GSV.[17,18] This compartment is situated deep in the hypodermis and extends from the ankle to the popliteal fossa.

The ML (which has been called in the past "fascia superficialis," "strasses bindegewebe," "Scarpa's fascia," "Camper's fascia," and "subcutaneous fascia") is actually a structure of the subcutaneous tissue,[16,20] formed by the interlacing of the connective sheets that constitute its fibrous skeleton.[17,18] The ML cannot be considered a duplication of the muscular envelope as suggested by several authors[11-15] because of its different embryological origins and course of fetal development.[21] As for the GSV, the portion of the ML that overlies the SSV could be called the "saphenous fascia."[17,18] At the lower leg, the saphenous fascia is consistent but thin and can be easily sectioned through a nonplanar dissection of the hypodermis. At the upper leg, the saphenous fascia is easily confused with the MF because it is thick and does not extend past the convex margin of the gastrocnemius muscle. In our study, dissections, stereomicroscopy, or ultrasonography never demonstrated the SSV piercing the MF at the leg[3-10] especially at the level of the gastrocnemius muscle and at the popliteal fossa where most texts state that the SSV becomes subfascial.

At the lower margin of the popliteal fossa, the MF, which represents the floor of the saphenous compartment, disappears from below the SSV to follow the bellies of the gastrocnemius muscle and diverges to gain attachment to the femoral condyles. The ML of the posterior leg bridges the popliteal fossa to reach the posterior thigh. Because of the particular arrangement of the MF and ML, the SSV crosses only the fat tissue of the popliteal fossa to reach the popliteal vein (or another of the deep veins of the posterior thigh). The popliteal fascia represents the upward extension of the posterior leg ML, reinforced in its peripheral portions by fibers from the fasciae of the gastrocnemius, semitendinosus, and biceps femoris muscles.[15]

In the past, the saphenous fascia and the interfascial course of the SSV has been ignored[2-8] or only partially described.[9-15] The discordant descriptions about the planar arrangement of the SSV[2-15] are probably due to the fact that the ML is easily missed at the lower leg and can be confused with the MF at the upper leg and at the popliteal fossa. Finally, confusion with regard to the planar anatomy of the SSV is also due to the presence of large accessory veins,[22] which course parallel to the saphenous trunk in a more superficial plane of the limb (above the ML) (Fig 5, *D*).

The SSV is anchored to the fibrous walls of the compartment in which it runs by means of a connective lamina. Such a structure has been described previously for the GSV[18] and could be considered as a sort of rudimentary "ligament." This rudimentary ligament connects the two branches of the duplicated SSV. Real duplication of an SSV segment is more frequent than for a segment of the GSV.[23]

Only the SSV tributary, communicating, and accessory veins correspond to the typical description of superficial veins[2] because they course just below the skin and are surrounded by loose and amorphous fat.[24]

The arrangement of the SSV termination is so variable and complex that an anatomical and functional investigation seem to be mandatory to better perform its surgical exposition.

It is well known that fascial relationships of a vein are significantly implied in its hemodynamics (venous muscular pumping) and physiopathology (protection against dilation). Consequently, the interfascial course of the SSV does not represent a mere anatomical concept. In the case of the SSV, the bilaminar wrapping is so close to the venous walls that muscular contraction could locally enhance the blood flow within the SSV, as already hypothesized for the GSV.[17,25-28] These anatomical findings also demonstrate that the saphenous fascia is arranged as a sort of shield that could mechanically protect the SSV trunk against dilative pathologic conditions (Fig 5, *F*). A possible prophylactic action of the saphenous fascia against dilatation, already hypothesized for the GSV,[17,18,24-29] would be further indicated for the SSV because the two fasciae are close to it. Such a hypothesis is supported by the lower incidence of SSV varicosis compared with the incidence of varicosis in the GSV.[3] Further studies are needed to corroborate these hemodynamics and physiopathologic hypotheses.

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