# Magnification Spot Radiographs Improve Assessment for Inferior Vena Cava Filter Fractures prior to Removal Compared to CT

Vlasios S. Sotirchos, MD, Scott O. Trerotola, MD, and S. William Stavropoulos, MD


## ABSTRACT

**Purpose:** To determine if magnification spot radiographs acquired before attempting inferior vena cava (IVC) filter removal have value in the assessment for filter fractures.

**Materials and Methods:** A retrospective review of complex IVC filter removals performed at a tertiary referral center from October 2015 to May 2017 was performed. Magnification spot radiographs (frontal and at least 2 oblique views) were obtained with the fluoroscopic unit in the procedure suite prior to venous access for filter removal. Patients were included in the study if a computed tomography (CT) scan of the abdomen/pelvis before filter removal was available. Ninety-six patients (47 women and 49 men) were included. Most removed filters were the Recovery/G2/G2X/Eclipse/Meridian (n = 28), the Günther Tulip (n = 26), and the Celect/Celect Platinum (n = 22). Blinded review of the pre-procedural CT scans and spot radiographs for the presence of filter fractures was performed by 2 interventional radiologists. Accuracy of each modality was assessed using the status of the explanted filter as the gold standard. Agreement between the 2 readers was assessed with the kappa statistic.

**Results:** Fractures were present in 27 explanted filters (28%). Accuracy of CT was 88% and 68% for readers 1 and 2, respectively, which increased to 98% and 97% with magnification spot radiographs. The kappa statistic was 0.12 for CT and 0.97 for spot radiographs.

**Conclusions:** Magnification spot radiographs acquired before attempting IVC filter removal improve detection of filter fractures and agreement among interventional radiologists. Therefore, these should be performed routinely to allow for optimal treatment planning.


## ABBREVIATION

IVC = inferior vena cava

Retrievable inferior vena cava (IVC) filters can offer protection from pulmonary embolism in select patients and can be removed when no longer indicated (1). Prolonged IVC filter dwell times have been associated with increased rates of complications, such as symptomatic filter penetration, migration, fracture, and filter-related deep venous thrombosis (2–4). Filter fractures are potentially lethal, as the fractured fragments can migrate to the heart and cause cardiac perforation (5,6). Intravascular fracture fragments can be removed successfully using percutaneous interventional techniques in a large percentage of patients (7,8). Since the approach to removal of a fractured filter is often different than removal of an intact filter, knowing about this complication may be important for procedure planning.

Pre-procedural imaging is an important component in the evaluation of patients prior to IVC filter removal.

From the Department of Radiology, Division of Interventional Radiology, Perelman School of Medicine at the University of Pennsylvania, 3400 Spruce St – 1 Silverstein, Philadelphia, PA, 19104. Received May 28, 2019; final revision received July 30, 2019; accepted August 1, 2019. **Address correspondence to** S.W.S.; E-mail: s.stavropoulos@pennmedicine.upenn.edu; Twitter handle: @swstav

S.O.T. is a paid consultant for BD Bard (Murray Hill, New Jersey), Lutonix (Maple Grove, Minnesota), Cook Medical (Bloomington, Indiana), B. Braun (Melsungen, Germany), Teleflex (Wayne, Pennsylvania), Adrenas (Raleigh, North Carolina), W.L. Gore (Newark, Delaware), and MedComp (Harleysville, Pennsylvania) and receives royalties from Cook Medical and Teleflex. S.W.S. is a paid consultant for BD Bard and receives research grants from Sillajen (Busan, South Korea). The other author has not identified a conflict of interest.

From the SIR 2018 Annual Scientific Meeting.



*J Vasc Interv Radiol 2020; 31:61–65*

https://doi.org/10.1016/j.jvir.2019.08.004

**EDITORS' RESEARCH HIGHLIGHTS**

- Magnification spot radiographs prior to inferior vena cava filter removal detect filter fractures that may be unrecognized on computed tomography.
- In this study, more than 1 in 4 patients had fractures.
- A variety of different filters were included in the study.
- Authors noted that prospective knowledge of fractures affected planning and execution of filter removal and potentially obviated complications associated with filter and fragment extraction.

Patients with chronic indwelling filters often undergo a computed tomography (CT) venogram to assess for complications, such as embedded tip, leg penetration, filter fracture, or thrombus (9–13). Magnification spot radiographs of the IVC filter can be acquired prior to the procedure, to assess for filter integrity (7,12–14). The purpose of this study was to determine if these magnification spot radiographs have value in the evaluation for IVC filter fractures prior to filter removal and to compare their accuracy to assessment with CT.

## MATERIALS AND METHODS

An institutional review board-approved retrospective review was performed using a quality assurance database of complex IVC filter removals (defined as those with prior failed retrieval, tip embedding, fracture, or closed-cell design requiring forceps or other advanced techniques for removal) from October 2015 to May 2017, in compliance with the Health Information Portability and Accountability Act. In all cases, endobronchial forceps were used during the IVC filter removal procedure (15,16). The quality assurance database contained information regarding the type of filter removed and filter integrity on inspection after removal (fractured vs not fractured).

All patients included in this study had a CT scan performed after the filter was placed and before filter removal. On the day of the planned removal, just before venous access was attempted, magnification spot fluoroscopic images in the procedure suite (frontal and at least 2 oblique views) were acquired as part of a standardized procedure performed in all complex filter retrievals (**Fig 1**). These high-resolution radiographs were obtained at maximum magnification with the fluoroscopic unit, ensuring that the main body of the filter was included in the field of view. Rotational cavography was then performed, followed by filter removal. The gold standard regarding the presence of a filter fracture was inspection of the explanted filter; presence of at least 1 fracture was considered positive.

The spot radiographs and pre-procedural CT scans of the abdomen/pelvis were retrieved from the Picture Archiving and Communication System and anonymized. Patients with incomplete or missing images were excluded (n = 27). Patients' electronic medical records were examined for demographic data. In all, ninety-six patients (47 women and 49 men) with a mean age of 55 years (range, 23–84 years) were included in the study. Removed filters included the Recovery/G2/G2X/Eclipse/Meridian (n = 28), Günther Tulip (n = 26), Celect/Celect Platinum (n = 22), Option/Option Elite (n = 9), Denali (n = 8), and OptEase (n = 3).

Two interventional radiologists with more than 10 years of experience in complex filter retrieval and more than 20 years of experience in interventional radiology (S.O.T., S.W.S.), who were blinded to the IVC filter status after retrieval, retrospectively reviewed the anonymized CT scans of the abdomen/pelvis and magnification spot radiographs for the presence of filter fractures. The readers classified the CT scans and radiographs as either negative or positive for at least 1 filter fracture. The CT scans were reviewed in multiple planes using a commercially available Digital Imaging and Communications in Medicine viewer (iNtuitionViewer, version 4.4.12.100; TeraRecon Inc, Foster City, California).

Sensitivity, specificity, and accuracy were calculated for each reader, for CT and magnification spot radiographs, using the status of the filter on inspection after removal as the gold standard. Interobserver agreement was assessed using the kappa statistic. Statistical analysis was performed using SPSS statistical software (version 23; SPSS, Chicago, Illinois).

## RESULTS

Fractures were present in 27 of 96 filters (28%). The distribution of IVC filter fractures among different filter types is presented in **Table 1**. Technical success for removal of the main body of the IVC filter was 100%. Technical success for removal of fractured filter fragments was 89% (31/35). The 4 fractured filter fragments not successfully removed were in the immediate extravascular IVC (n = 3) and in the right ventricle (n = 1). Removal was not attempted for 13 fractured filter fragments (**Fig 2**).

The median time interval between the pre-procedural CT studies and the removal procedures was 23 days (range, 0–422 days). Accuracy of CT for the assessment of filter fractures was 89% (85/96) and 68% (65/96) for readers 1 and 2, respectively, which increased to 98% (94/96) and 97% (93/96) on magnification spot radiographs. Sensitivity for spot radiographs was 93% (25/27) for both readers, with the same 2 false-negative cases. In 1 case, the fractured strut was retrospectively seen on the CT, and in the second case it is possible that manipulation of the filter during the removal procedure led to fracture of a thin wire of a Günther Tulip filter.

Sensitivity, specificity, and accuracy for CT and magnification spot radiographs for each reader are presented in

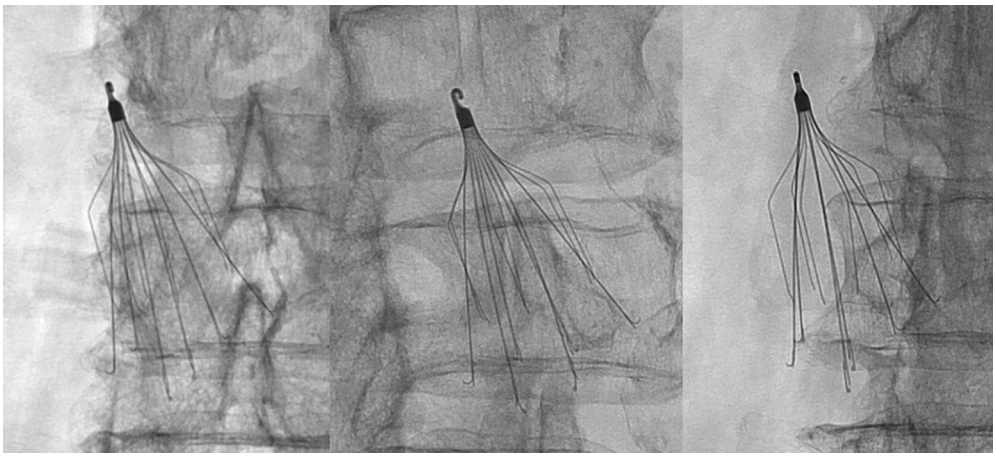

**Figure 1.** High-resolution frontal and 2 oblique (right anterior oblique and left anterior oblique at 45°) magnification spot radiographs obtained with the fluoroscopic unit demonstrate an intact, mildly angulated Denali IVC filter.

**Table 1.** Distribution of IVC Filter Fractures among Different IVC Filter Types

| Filter Type | No Fracture | Fracture | Total |
|---|---|---|---|
| Recovery/G2/G2X/Eclipse/Meridian | 11 | 17 | 28 |
| Günther Tulip | 21 | 5 | 26 |
| Celect/Celect Platinum | 19 | 3 | 22 |
| Option/Option Elite | 8 | 1 | 9 |
| Denali | 7 | 1 | 8 |
| OptEase | 3 | 0 | 3 |

Table 2. The kappa statistic was 0.12 (poor agreement) for CT and 0.97 (almost perfect agreement) for spot radiographs.

## DISCUSSION

Fracture of retrievable IVC filters is a well-recognized complication, which was increasingly identified in the late 2000s (5,6), leading to 2 U.S. Food and Drug Administration advisories (17,18). Prolonged dwell times are associated with this complication (3,19–21). The reported incidence of IVC filter fracture varies widely in the literature, as high as 38% in 1 study (22). There was a high percentage of fractured IVC filters (27%) in this cohort, noting, however, the presence of selection bias, as this study was performed at a referral center for management of filter complications. This was advantageous to the study design, as it allowed inclusion of a meaningful number of filter fractures. On the other hand, the limited sample size (n = 96) was not sufficient to lead to generalizations regarding the true prevalence of fractures among different filter types.

Magnification spot radiographs using the fluoroscopic unit prior to obtaining venous access are routinely acquired at the current institution, which is a tertiary referral center specializing in complex filter retrieval. The rationale for these radiographs is to better assess for IVC filter fractures, using the increased spatial resolution of this modality compared to CT. The interventional radiologist should be aware of the presence and number of filter fractures, as well as their location. If all components of the filter cannot be accounted for on the spot radiographs, additional spot views of the thorax can be obtained for identification of possible embolized fragments in the heart or pulmonary circulation. Furthermore, in the presence of a free-floating or intravascular fragment, it may be preferable to remove the fragment before attempting to remove the main filter body, in an effort to minimize the risk of fragment migration centrally, which is a potentially catastrophic scenario (5,6,8). These free-floating fragments may be more conspicuous on the magnification spot radiographs (Fig 3). In addition, it is important to document the presence of IVC filter fractures prior to the retrieval attempt for medico-legal purposes, as manipulation of the filter may also cause fractures, especially with use of advanced retrieval techniques (23). Because of the frequent technical modifications required for removal of a fractured filter and the potentially severe complications from central migration of fractured filter fragments, it can be hypothesized that the benefit of the added information from these radiographs outweighs the risks associated with the small increase in radiation exposure during the procedure.

Due to the retrospective nature of this study, the frequency of which the spot radiographs changed patient management and the approach to the IVC filter removal could not be estimated. The study readers, as mentioned, are interventional radiologists, not fellowship-trained body/cardiovascular imaging diagnostic radiologists. Thus, the lower accuracy for the detection of fractures on the CT scans could in theory be attributed to the readers' subspecialty; however, both study readers have extensive experience in the interpretation of CT venograms prior to IVC removal, and it has be shown that IVC filter-related complications are underreported by diagnostic radiologists, even after the implementation of standardized

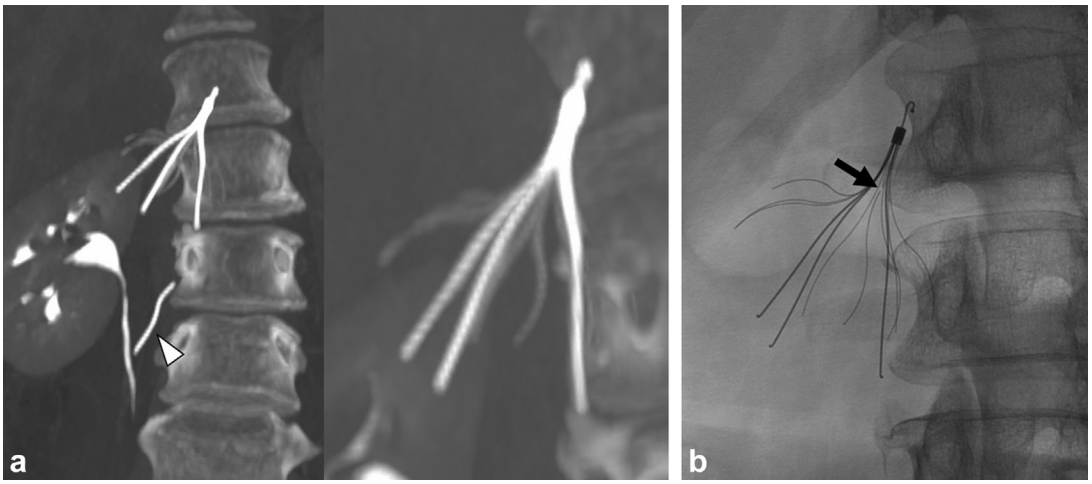


**Figure 2.** (**a**) Curved coronal CT images using maximum intensity projection show a tilted and deeply embedded Celect IVC filter, as well as a fractured filter leg that migrated caudally in the right retroperitoneum, passing through the right psoas muscle (white arrowhead). No other filter fracture was visualized on the CT. (**b**) Magnification spot radiograph (left anterior oblique) of the filter acquired just before the removal procedure, 10 weeks after the CT scan, show an additional minimally displaced leg fracture (black arrow). This fracture is not visible on the other magnification spot radiographs or on the CT, even in retrospect. The main body of the filter and the minimally displaced fracture fragment were successfully removed using endobronchial forceps. The distal retroperitoneal fragment was extravascular, and removal was not attempted.

**Table 2.** Sensitivity, Specificity, and Accuracy of CT and Magnification Spot Radiographs for Each Reader

| | CT | | Magnification Spot Radiographs | |
|---|---|---|---|---|
| | **Reader 1** | **Reader 2** | **Reader 1** | **Reader 2** |
| Sensitivity | 17/27 (63%) | 9/27 (33%) | 25/27 (93%) | 25/27 (93%) |
| Specificity | 68/69 (99%) | 56/69 (81%) | 69/69 (100%) | 68/69 (99%) |
| Accuracy | 85/96 (89%) | 65/96 (68%) | 94/96 (98%) | 93/96 (97%) |
| | k = 0.12 | | k = 0.97 | |

k = kappa statistic.

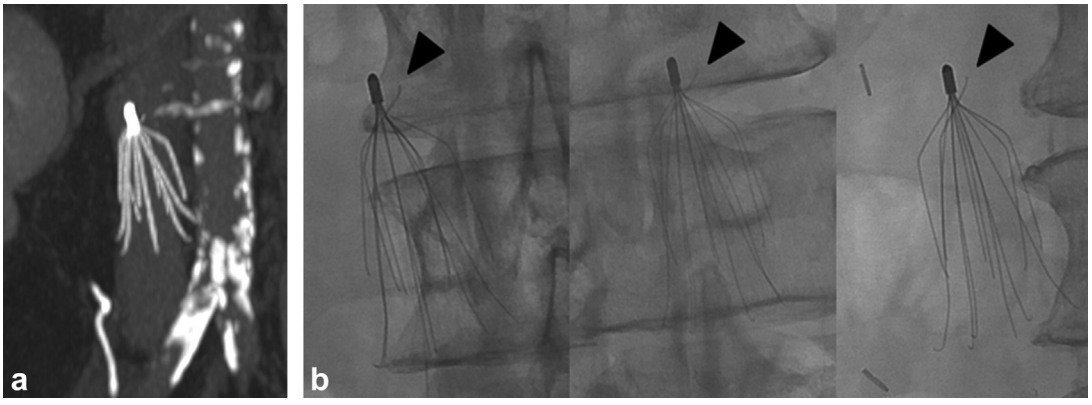


**Figure 3.** (**a**) Coronal CT image using maximum intensity projection shows a G2 IVC filter. No filter fracture was visualized by the 2 study readers or the body radiologist interpreting the study. (**b**) A frontal and 2 oblique magnification spot radiographs in the same patient after 2 weeks show a fractured filter arm (black arrowheads). Knowledge of this was important for procedure planning, as a cavogram was not performed in the presence of a free intravascular fragment for fear of dislodging it while placing the diagnostic catheter. The fractured arm was first removed using endobronchial forceps and was clearly loose in the filter based on how easily it was removed. In retrospect, the fractured arm could be visualized on the CT scan; however, it was more conspicuous on the radiographs.

templates (24). Another limitation of this study was that the reviewed CT scans were performed with different imaging protocols, as many patients underwent preprocedural imaging at outside institutions. In addition, it is possible that some of the fractures seen on magnification spot radiographs at the time of the procedure developed after the CT scan, leading to incorrect classification of CT studies as false negative, although the median time from CT to filter removal was 23 days. Finally, using filter inspection as the gold standard had the risk of including fractures occurring with manipulation of the filter during the removal procedure; however, all but 1 fracture could be visualized in retrospect on the spot radiographs.

In conclusion, magnification spot radiographs acquired before attempting IVC filter removal improve detection of filter fractures and agreement among interventional radiologists. Therefore, these should be performed routinely to allow for optimal treatment planning.

## REFERENCES


1. Kaufman JA, Kinney TB, Streiff MB, et al. Guidelines for the use of retrievable and convertible vena cava filters: report from the Society of Interventional Radiology Multidisciplinary Consensus Conference. J Vasc Interv Radiol 2006; 17:449–459.
2. Angel LF, Tapson V, Galgon RE, Restrepo MI, Kaufman J. Systematic review of the use of retrievable inferior vena cava filters. J Vasc Interv Radiol 2011; 22:1522–1530.e3.
3. McLoney ED, Krishnasamy VP, Castle JC, Yang X, Guy G. Complications of celect, günther tulip, and greenfield inferior vena cava filters on CT follow-up: a single-institution experience. J Vasc Interv Radiol 2013; 24:1723–1729.
4. Zhou D, Moon E, Bullen J, Sands M, Levitin A, Wang W. Penetration of Celect inferior vena cava filters: retrospective review of CT scans in 265 patients. AJR Am J Roentgenol 2014; 202:643–647.
5. Nicholson W, Nicholson WJ, Tolerico P, et al. Prevalence of fracture and fragment embolization of Bard retrievable vena cava filters and clinical implications including cardiac perforation and tamponade. Arch Intern Med 2010; 170:1827–1831.
6. Hull JE, Robertson SW. Bard Recovery Filter: Evaluation and management of vena cava limb perforation, fracture, and migration. J Vasc Interv Radiol 2009; 20:52–60.
7. Trerotola SO, Stavropoulos SW. Management of fractured inferior vena cava filters: outcomes by fragment location. radiology 2017; 284:887–896.
8. Kesselman AJ, Hoang NS, Sheu AY, Kuo WT. Endovascular removal of fractured inferior vena cava filter fragments: 5-year registry data with prospective outcomes on retained fragments. J Vasc Interv Radiol 2018; 29:758–764.
9. Lee MJ, Valenti D, de Gregorio MA, Minocha J, Rimon U, Pellerin O. The CIRSE retrievable ivc filter registry: retrieval success rates in practice. Cardiovasc Intervent Radiol 2015; 38:1502–1507.
10. Wang SL, Siddiqui A, Rosenthal E. Long-term complications of inferior vena cava filters. J Vasc Surg Venous Lymphat Disord 2017; 5:33–41.
11. Desai K, Pandhi MB, Seedial SM, et al. Retrievable IVC filters: comprehensive review of device-related complications and advanced retrieval techniques. Radiographics 2017; 37:1236–1245.
12. Dinglasan LAV, Trerotola SO, Shlansky-Goldberg RD, Mondschein J, Stavropoulos SW. Removal of fractured inferior vena cava filters: feasibility and outcomes. J Vasc Interv Radiol 2012; 23:181–187.
13. Duncan C, Trerotola SO, Stavropoulos SW. Endovascular removal of inferior vena cava filters with arterial penetration. J Vasc Interv Radiol 2018; 29:486–490.
14. Stavropoulos SW, Dixon RG, Burke CT, et al. Embedded inferior vena cava filter removal: use of endobronchial forceps. J Vasc Interv Radiol 2008; 19:1297–1301.
15. Stavropoulos SW, Ge BH, Mondschein JI, Shlansky-Goldberg RD, Sudheendra D, Trerotola SO. Retrieval of tip-embedded inferior vena cava filters by using the endobronchial forceps technique: experience at a single institution. Radiology 2015; 275:900–907.
16. Chen JX, Montgomery J, McLennan G, Stavropoulos SW. Endobronchial forceps-assisted and excimer laser-assisted inferior vena cava filter removal: the data, where we are, and how it is done. Tech Vasc Interv Radiol 2018; 21:85–91.
17. U.S. Food and Drug Administration. Removing Retrievable Inferior Vena Cava Filters: Initial Communication. Available at: https://wayback.archive-it.org/7993/20161022180008/http:/www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm221676.htm. Accessed May 7, 2019.
18. U.S. Food and Drug Administration. Removing Retrievable Inferior Vena Cava Filters: FDA Safety Communication. Available at: https://wayback.archive-it.org/7993/20170111070016/http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm396377.htm. Accessed May 7, 2019.
19. Sarosiek S, Crowther M, Sloan JM. Indications, complications, and management of inferior vena cava filters: the Experience in 952 Patients at an academic hospital with a level I trauma center. JAMA Intern Med 2013; 173:513–517.
20. Morris E, Duszak R, Sista AK, Hemingway J, Hughes DR, Rosenkrantz AB. National trends in inferior vena cava filter placement and retrieval procedures in the medicare population over two decades. J Am Coll Radiol 2018; 15:1080–1086.
21. Tam MD, Spain J, Lieber M, Geisinger M, Sands MJ, Wang W. Fracture and distant migration of the bard recovery filter: a retrospective review of 363 implantations for potentially life-threatening complications. J Vasc Interv Radiol 2012; 23:199–205.
22. An T, Moon E, Bullen J, et al. Prevalence and clinical consequences of fracture and fragment migration of the bard G2 filter: imaging and clinical follow-up in 684 implantations. J Vasc Interv Radiol 2014; 25:941–948.
23. Kuyumcu G, Walker TG. Inferior vena cava filter retrievals, standard and novel techniques. Cardiovasc Diagn Ther 2017; 6:642–650.
24. Shin BJ, Habibollahi P, Zafar H, Hilton S, Stavropoulos SW, Trerotola SO. Reporting of inferior vena cava filter complications on CT: impact of standardized macros. AJR Am J Roentgenol 2018; 211:439–444.