



## Vascular Interventions Case Report

# Self-centering of the Cook Celec inferior vena cava filter

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## ABSTRACT

A patient who underwent placement of an inferior vena cava (IVC) filter before total knee arthroplasty with a history of venous thromboembolism following knee replacement 10 years prior. Difficulty releasing the filter during delivery resulted in approximately 17° of medial tilt of the filter apex. Follow-up computed tomography after arthroplasty 4 months after placement demonstrated that the filter self-centered in the IVC with subsequent straightforward retrieval.

**Keywords:** Inferior vena cava filter, Inferior vena cava filter tilt, Deep venous thrombosis, Pulmonary embolism

## INTRODUCTION

Inferior vena cava (IVC) filter tilt is a known outcome of IVC filter placement with 15° or greater tilt relative to the long axis of the IVC as a known insertion complication.<sup>[1]</sup> If this occurs, the general recommendation is for repositioning of the filter at the time of placement. Fifteen degrees or greater tilt is reported to be less effective in preventing pulmonary embolism and may result in a more difficult retrieval. Filter tilt with subsequent embedding of the hook of the filter into the IVC wall is frequently cited for inability to retrieve the filter.<sup>[2-7]</sup> We present a case of a patient undergoing prophylactic placement of an IVC filter for a total knee arthroplasty with tilting of the filter at placement. This was followed by delays in the patient's planned surgery as a result of COVID-19 and delayed filter retrieval.

## CASE REPORT

A patient with a history of venous thromboembolism following left knee replacement 10 years previously for which they were treated with oral anticoagulation for 6 months. They subsequently developed severe pain in their right knee refractory to medical therapy. The patient underwent arthroscopy without significant improvement. Total knee arthroplasty was planned with placement of an IVC filter before right total knee arthroplasty given their prior thromboembolism and bleeding on anticoagulation. The implanted filter used was the Cook Celec (Cook Medical, Inc., Bloomington, IN) retrievable IVC filter. During the initial deployment of the filter, there was difficulty in releasing the filter resulting in approximately 17° of medial tilt [Figure 1]. The filter was left in place with the plan to remove the filter following the patient's knee replacement in 3 weeks. Surgery was subsequently delayed 4 months as a result of the COVID-19 pandemic.

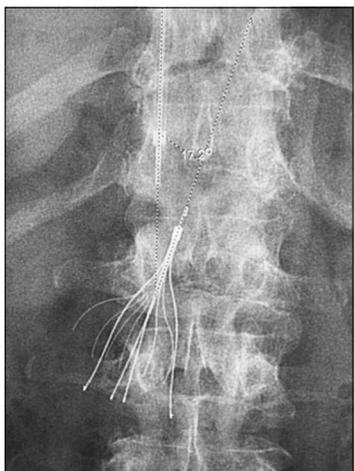
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Follow-up computed tomography (CT) was performed in June before removal of the IVC filter which demonstrated that the tilt had resolved with the filter centered in the IVC [Figure 2]. Subsequent removal of the filter was then performed without complication with standard technique utilizing a guidewire, sheath, and snare with the hook accessible in the center of the IVC. Total dwell time of IVC filter was 4 months.

## DISCUSSION

Complications of IVC filter placement include filter tilt, migration, perforation, thrombosis, incomplete opening,



**Figure 1:** A patient with a history of venous thromboembolism undergoing prophylactic placement of an inferior vena cava filter before knee replacement. Intraprocedural fluoroscopic image during placement of the filter demonstrating approximately 17° of medial tilt.



**Figure 2:** A patient with a history of venous thromboembolism undergoing prophylactic placement of an inferior vena cava (IVC) filter before knee replacement. Coronal reformat of contrast-enhanced abdominal computed tomography before retrieval demonstrating straightening of the filter in the IVC.

as well as operator errors such as placement in non-target locations and incorrect orientation.<sup>[1,7-9]</sup> IVC filter tilt <15° has been shown to significantly improve the odds of an uncomplicated filter retrieval.<sup>[5]</sup> Filter tilt >15° is also associated with increased risk of PE, ineffectiveness of filtration, increased incidence of caval perforation, IVC thrombosis, pulmonary embolism, and difficult retrieval as well as migration of the filter. Theorized causes of filter tilt include caval shape, delivery approach, and equipment factors.<sup>[2]</sup> Techniques have been described for correcting filter tilt during placement, including a technique of using a stiff wire placed through the sheath to straighten the filter.<sup>[10]</sup>

In a study of the Gunther Tulip filter (Cook Medical, Inc., Bloomington, IN), it was demonstrated that the most significant factors for retrieval failure were failure to snare the hook and failure to advance the sheath over the filter, with 8 of the 44 failed retrievals attributed to excessive tilt of the filter.<sup>[8]</sup> However, no significant association was found between the degree of filter tilt and retrieval success in that study. Similarly, Avgerinos *et al.* found filter tilt to be a predictor of difficult retrieval but ultimately did not contribute to retrieval failure.<sup>[3]</sup>

Studies have shown an association with increased dwell time and difficult retrieval, with longer dwell times and tilted filters contributing to increased endothelial growth over the hook of the filter, making unsuccessful retrieval more likely.<sup>[2-9]</sup> Glocker *et al.* demonstrated that dwell time of >117 days was significantly associated with unsuccessful retrieval. In addition, filter tilt of >20° was also associated with unsuccessful retrieval.<sup>[4]</sup> Endothelial tissue traps the hook against the wall of the IVC making snaring difficult.

In our case, repositioning of the filter was considered. The risks of reorienting, particularly bleeding, prolonged procedure time, worsening tilt, and damaging or dislodging the filter, were weighed against the possible benefit of more straightforward retrieval. The original plan was to remove the filter 3 weeks after placement, limiting the opportunity for endothelial growth around the hook. Consideration was also given to the reported cases in the literature demonstrating self-centering of filters.<sup>[7,9]</sup> For these reasons, the decision was made to leave the filter in place as it was oriented and removed it following the total knee replacement. The unanticipated COVID-19 pandemic and subsequent quarantine resulted in procedural delays and longer dwell time.

On review of the imaging, it appeared that during the deployment, a side arm of the filter retracted and contributed to an orientation of approximately 17°. No portion of the filter entered the right renal vein nor could an adjacent venule be identified. The reason for retraction of the side arm was likely related to back tension intended to straighten the

delivery system within the IVC, which subsequently resulted in difficulty releasing the hook of the filter. Care should be given during deployment to keep the delivery system centered with minimal back tension applied at the moment of filter release. As a result of tension on the deployed filter legs, the tensile and rotational forces retracted the side arm and pulled the hook medially.

Smouse *et al.* demonstrated in ovine models that Cook Celect filters demonstrated self-centering in five of eight cases of those filters that were tilted at implantation.<sup>[9]</sup> Lyon *et al.* similarly found the secondary arms to improve self-centering of the Cook Celect filter with 18 of 58 filters tilted at implantation having lesser degrees of tilt at retrieval.<sup>[7]</sup> However, 10 of the 58 filters with tilt at implantation demonstrated increased tilt at retrieval. Although not statistically significant, filters with  $>10^\circ$  of tilt did demonstrate some degree of self-centering at retrieval. Thirty filters with tilt at placement stayed at the same degree of tilt. Difficulty associated with filter retrieval was attributed to inability to snare the hook due to endothelial ingrowth in those filters with significant tilt.

One explanation for the self-centering includes the dynamic environment of the IVC during hemodynamic variations and hydration states exerting forces on the filter. In addition, design elements such as side arms help to stabilize and straighten the filter within the IVC.<sup>[7,9]</sup> Factors external to the IVC such as surrounding organs and movement of the patient may also contribute to filter movement.

Until more data are available, it is difficult to determine whether self-centering filters will impact patient outcomes given the array of filters in use and limited research in this area. Further research and more case reviews of filter follow-up are needed to inform clinical decision-making in regard to readjusting the filter at the time of deployment. The degree of filter tilt where the recommendation would be to attempt repositioning also could be refined and perhaps the threshold for acceptable tilt increased.

## CONCLUSION

Based on this case and subsequent review of the literature, we believe that filter position at the time of deployment is a poor predictor of position at the time of retrieval and that filter tilt, while possibly leading to decreased efficacy and more difficult retrieval, should not be regarded by itself as a complication. Further research into the degree of acceptable tilt and the need for additional measures at placement to correct tilt is needed. Numerous factors contribute to filter position at retrieval and advances in filter design contribute to improved stability and self-centering demonstrated in our case and described previously. A recent 2016 study examined using pre-retrieval CT to predict complicated

filter retrieval as defined as the use of non-standard retrieval techniques.<sup>[6]</sup> Complicated retrieval was more likely with a dwell time of  $>45$  days and pre-retrieval CT may be helpful to evaluate for tilt, tip embedment, and perforation, thus predicting more challenging retrieval. Pre-retrieval CT may be appropriate in cases where there is concern for excessive filter tilt at deployment as well as in cases where the dwell time of the filter was  $>45$  days. In cases where imaging demonstrates the filter apex is against the IVC wall, plans can then be formulated for advanced maneuvers such as use of endobronchial forceps or other techniques.

## Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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## Conflicts of interest

There are no conflicts of interest.

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