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A Makeshift Blue Light Filter for Endoscopic Identification of Traumatic Cerebrospinal Fluid Leak Using Fluorescein

ABSTRACT

Objective: To describe a makeshift blue light filter for endoscopic visualization of a traumatic cerebrospinal fluid leak repair using intrathecal fluorescein and its application in one patient.

Methods:

Study Design:	Surgical Instrumentation
Setting:	Tertiary Government Training Hospital
Patient:	One

Results: Intra-operative endoscopic identification of fistulae sites was achieved using intrathecal injection of fluorescein that fluoresced using our makeshift blue light filter in a 43-year-old man who presented with a 3-month history of rhinorrhea due to skull base fractures along with multiple facial and upper extremity fractures he sustained after a fall from a standing height of 6 feet. He underwent transnasal endoscopic repair of cerebrospinal fluid fistulae in the planum sphenoidale, clivus and sellar floor. Post-operatively, there was complete resolution of rhinorrhea with no complications noted.

Conclusion: Our makeshift blue light filter made from readily available materials may be useful for endoscopic identification of CSF leaks using fluorescein in a low- to middle-income country setting like ours.

Keywords: *rhinorrhea; CSF leak; cerebrospinal fluid fistula; basilar skull fracture; posterior cranial fossa; post-traumatic cerebrospinal fluid leakage; blue light filter, endoscopic CSF leak repair, clivus*

Cerebrospinal fluid leak is classified into traumatic or spontaneous (non-traumatic) based on etiology.[1] Traumatic skull fractures typically result in dura and arachnoid tears which lead to cerebrospinal fluid (CSF) leaking into the nasal cavity, paranasal sinuses, and middle ear and approximately 80% of CSF leaks are caused by head injuries with craniofacial fractures.[2] Accidental head trauma carries a 32% overall risk of developing meningitis, significantly higher than iatrogenic trauma and spontaneous leaks at 22% and 10%, respectively.[3-5] Therefore, appropriate

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investigation and timing of the surgical repair are crucial and depend on the identification of CSF leaks. Several localization techniques for CSF leaks can be utilized including computed tomography scan with or without cisternography, magnetic resonance imaging with or without cisternography, and tracer studies with intrathecal fluorescein being the preferred technique. [1]

Intrathecal fluorescein can be used off-label for localization of multiple CSF leak sources, but a blue light filter is still needed for visualization.[6] In areas where a blue light filter is not available, a makeshift blue light filter can be devised using low-cost materials. To the best of our knowledge, based on a search of HERDIN Plus, the ASEAN Citation Index (ACI), the Western Pacific Region Index Medicus (WPRIM), the Directory of Open Access Journals (DOAJ), MEDLINE (PubMed and PubMed Central), and Google Scholar using the search terms "blue light," "blue light filter," "CSF leak blue light filter," and "CSF leak repair ," we did not find any innovation of a makeshift blue filter for endonasal CSF fluorescein visualization. Since commercially available blue light filters are costly and pre-made for specific endoscopes and light sources, we sought to develop a makeshift blue light filter that can be both economical and effective especially in developing countries like ours.

We describe our makeshift blue light filter for endoscopic visualization of a traumatic cerebrospinal fluid leak repair using intrathecal fluorescein, and its application in one patient.

METHODS

We used a commercially available acetate face shield (Philippine Blue Cross Biotech Corporation, Philippines), one violet permanent marker, fine-tipped, super color marker (SC-F, Pilot, Japan), one blue permanent marker (blue permanent marker, fine-tipped, super color marker (SC-F), Pilot, Japan) a 10-centavo coin (BSP coin series, 1995 issue, *Bangko Sentral ng Pilipinas*, Philippines), and a 3-0, 45cm length, black braided silk suture with SH-1, 22mm ½ circle, taper needle (PERMA-HAND C003D, Ethicon, USA) to mimic the filtering effect. *(Figure 1A)* Since the port diameter of our portable light source (5-Watt ES201 Compact LED light source, Firefly Global, USA) was 1.1 cm, a 10-centavo coin which measured 1.3 cm to produce a round shape was used to fit the light source port with slight overcorrection of measurement for a snug fit.

To construct a blue light filter, three 1.3-cm circles were traced around the coin on the acetate, shaded entirely with single-layered horizontal parallel strokes using the permanent markers, and cut out. *(Figure 1B, C)* To produce the effect of the blue light filter, sets of two circles shaded blue and one circle shaded violet were made. For each set, a violet circle was placed in between two blue circles and they were sutured together for easy removal from the light source. *(Figure 1D, E)*

RESULTS

With approval from the JRRMMC Institutional Review Board (JRRMMC IRB 2021-161) and informed consent, we utilized our makeshift blue light filter in a 43-year-old man who presented with a 3-month history of rhinorrhea due to skull base fractures along with multiple facial and upper extremity fractures he sustained after a fall from a standing height of 6 feet while picking an avocado from the tree. He lost consciousness for one hour and had epistaxis. Clear, watery nasal discharge was observed on the 6th day of admission in a local hospital. Plain cranial computed tomography scans revealed intracranial hematoma and multiple craniofacial fractures and he was transferred to our institution. There was no significant improvement with or response to medical management of the suspected CSF leak for one month, and the patient was referred to us for surgical repair of the traumatic CSF leak. Nasal endoscopy revealed no lesions in both nasal cavities and no actively draining fluid even on Valsalva maneuver. A halo test was negative since the watery nasal discharge was not mixed with blood while a positive reservoir sign was observed. Computed tomography cisternography with supplemental contrast-enhanced CT scans of the head revealed post-traumatic CSF fistulae secondary to sphenoid sinus and sellar floor fractures, multiple craniofacial fractures, pneumocephalus, and resolving right inferior frontal lobe abscess.

The patient underwent transnasal endoscopic repair of the planum sphenoidale, clivus, and sellar floor using tensor fascia lata, abdominal fat graft, and nasoseptal flap. Before general anesthesia induction, the awake patient was positioned preoperatively in left lateral decubitus for sterile insertion of a lumbar catheter. *(Figure 2A)* Around 10 ml of cerebrospinal fluid (CSF) was slowly withdrawn and mixed with 0.1 ml of sterile 10% fluorescein sodium (Contacare Ophthalmics and Diagnostics, India) and then reinjected slowly over a period of several minutes while monitoring for any adverse reaction. *(Figure 2B)* In order to visualize the fluorescein injection into the CSF and properly identify the location of the CSF fistulae, the makeshift blue light filter that was made preoperatively for our portable light source was utilized intraoperatively. *(Figure 1F)*

Three hours post-injection, fluorescein fully fluoresced using the blue light filter, allowing identification and differentiation between CSF and nasal secretions. (Figure 3) The patient was repositioned with the head slightly elevated at 15 degrees. Bilateral sphenoidotomy with preservation of turbinates were performed prior to flap elevation.

A left-sided nasoseptal flap was harvested prior to opening the sphenoid sinus. To fully visualize the sphenoid sinus and skull base, the rostrum was drilled down and the middle and superior turbinates on the right were lateralized as well. At this point, the sphenoid intersinus septum and sphenoid mucosa were visualized alongside yellow-colored soft tissue and a bulge on the mucosa containing fluorescein. *(Figure 4A)* On correlation with the preoperative CT scan, the mass appeared isodense with brain tissue and it seemed to protrude from a skull base defect on the planum sphenoidale. *(Figure 4B, C, D)* The makeshift blue light filter was used to evaluate the yellowish soft tissue and check if it was surrounded by or stained with fluorescein. The soft tissue did not fluoresce compared to the other tissues that had CSF with fluorescein. *(Figure 5A, B)* Posterior to the herniated soft tissue there was also CSF leakage which was identified using the makeshift blue light filter. *(Figure 5C, D)* The neurosurgery service confirmed the suspicion that it was a herniated pituitary gland. The remnants of sphenoid sinus mucosa were further removed by drilling the intersinus septum and bony separation of the Onodi cell from the sphenoid. The mucosa surrounding the sellar floor defect was also removed.

A total of 3 differently located defects that were irregularly shaped were identified, and three layers of repair were used—abdominal fat graft, tensor fascia lata graft, and nasoseptal flap. Abdominal fat graft plugs were primarily placed into the sellar floor defect. Prior to placement of succeeding layers of repair, the makeshift blue light filter was used to check for other unaddressed areas of CSF leak. There was no detected fluorescence signifying that all areas were repaired. *(Figure 5E, F)* One fascia lata graft was used as inlay then another fascia lata graft and nasoseptal flap as onlay layers of repair. Additional abdominal fat graft was placed anterior to the nasoseptal flap to serve as additional support. Hemostasis was achieved, and an intranasal Foley catheter balloon (7 cc of sterile water) was inflated anterior to the layers of repair and an intranasal bioresorbable pack (Netcell PVA nasal pack, hydroxylated polyvinyl acetate, Network Medical Products, United Kingkdom) was placed inferior to the balloon as additional support.

There was no post-operative rhinorrhea, bleeding or changes in vision. There was no CSF leakage after removal of the intranasal Foley catheter and bioresorbable nasal pack on day 7 and the patient was discharged. He remained well with no CSF leaks on one week and four weekly follow ups when nasal endoscopy showed crust formation around the anterior abdominal fat graft.

DISCUSSION

We successfully fabricated a makeshift blue light filter and applied it in our patient with CSF leak. The makeshift filter aided in localization of the CSF leak and evaluation of post-repair CSF leakage. We discovered intraoperatively that around 2 minutes is the ideal time to maximize its light frequency blocking effect and form. Beyond this would lead to discoloration and deformation of the acetate filter.

Fluorescein sodium is a dye that that emits light of wavelength 520-530 nm or green-yellow, and fluoresces when excited by light with wavelength of 465 – 490 nm, represented by the blue spectrum.[7] In order to create a blue light filter to visualize the fluorescence, a blue-pass filter and a green-yellow-pass barrier filter must be used to separate the image of the fluorescein from background illumination.[8] By definition, filters are designed to have absorption characteristics that block light at undesired frequencies and allow light in its passband to pass through.[6] The use of blue light filter contributes to better visualization of CSF leak sites.[9] Fluorescein can be injected intrathecally by mixing 0.1ml of 10% fluorescein with 10ml of the patient's CSF injected over a period of 10 minutes and the dye is allowed to circulate for approximately 1-3 hours.[3] In our case, the fluorescence was detected 3 hours post-injection using our makeshift blue light filter. Guided by these principles in visualizing fluorescein, we were able to fabricate a makeshift blue light filter that

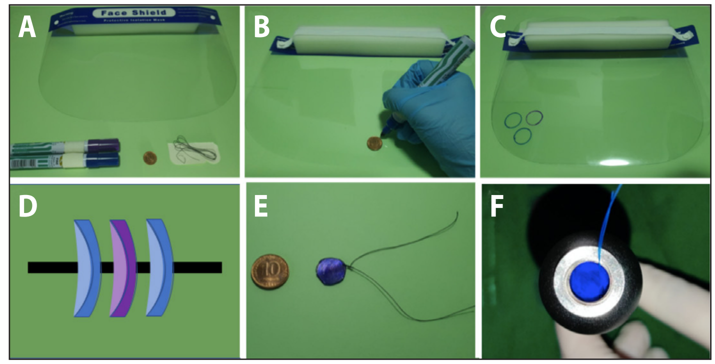

Figure 1. Preparation of the makeshift blue light filter: **A.** materials include commercially available face shield, two permanent markers (blue and violet), 10-centavo coin, silk suture (or any suture of your preference); **B.** and **C.** tracing a circular shape using the 10-centavo coin and permanent marker; **D.** arranging the shaded circular acetate pieces with the violet shaded circle in between two blue circles; **E.** suturing the 3 pieces together; and **F.** positioning the makeshift blue light filter within the light source port.

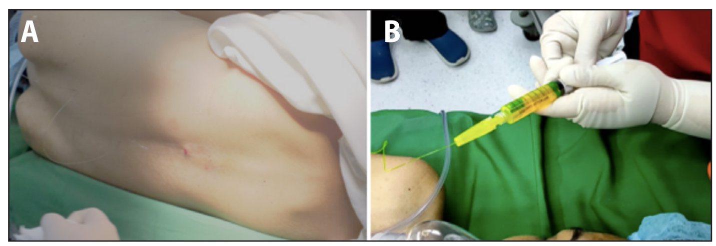

Figure 2. Intrathecal injection of 10% fluorescein: **A.** left lateral decubitus positioning of patient for insertion of lumbar catheter; **B.** withdrawn CSF was mixed with 0.1 ml of sterile 10% fluorescein sodium and then reinjected into the patient over a period of several minutes.

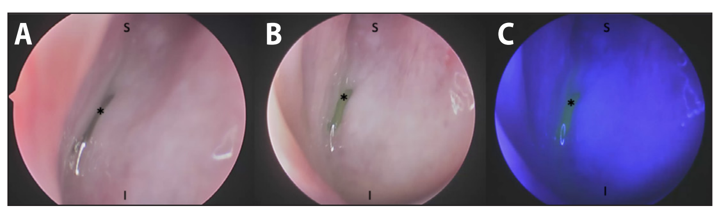

Figure 3. Intraoperative visualization: **A.** clear watery nasal discharge from right sphenoid sinus ostium (asterisk); **B.** white light; and **C.** blue light, showing egress of CSF admixed with fluorescein three hours post-injection. S, superior; I, Inferior.

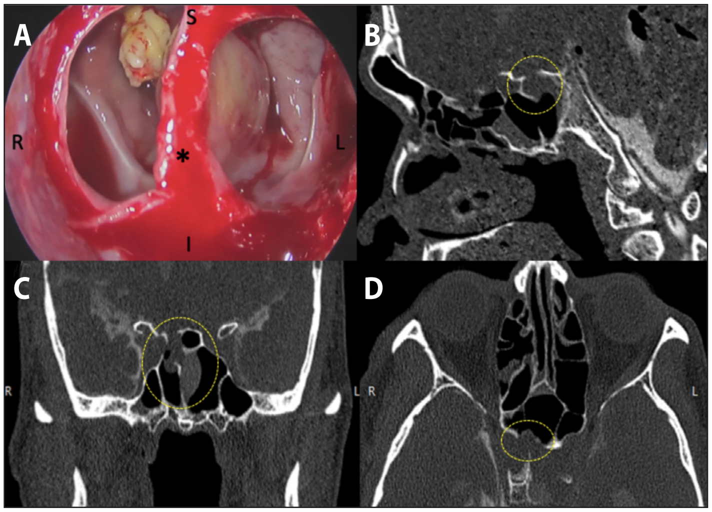

Figure 4. Visualization of the sphenoid intersinus septum and mucosa: **A.** right side (R) of the intersinus septum (asterisk) shows yellow-colored unstained soft tissue; left (L) bulge on the mucosa contains fluorescein, correlating with encircled areas in **B.** sagittal, **C.** coronal, and **D.** axial CT scan views. S, superior.

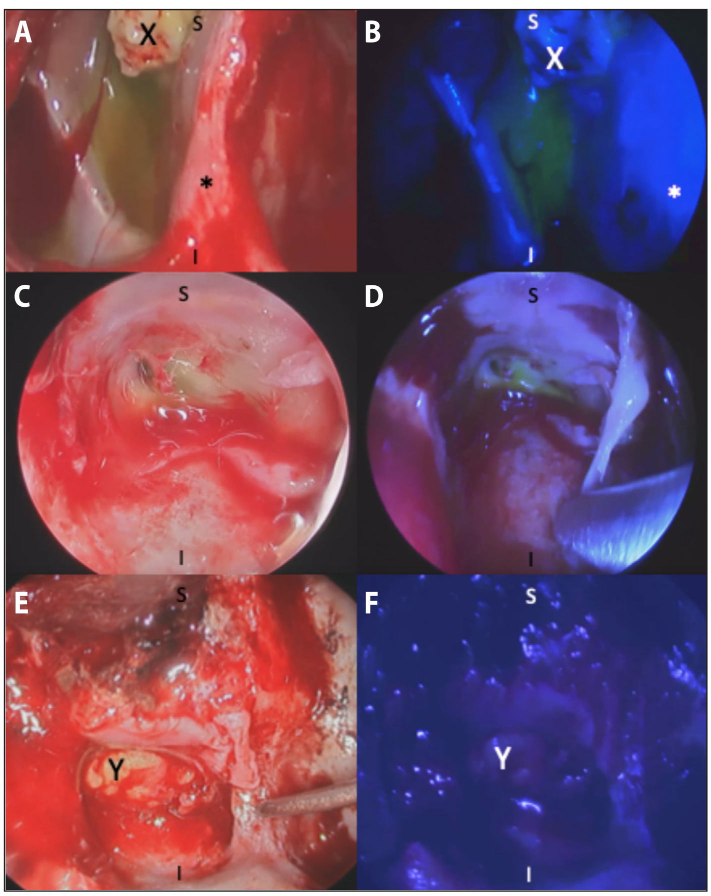

Figure 5. Comparative images **A.** without, and **B.** with makeshift blue light filter to evaluate the herniated soft tissue demonstrates no fluorescence; **C.** sellar floor defect under white light and **D.** under blue light showing fluorescence; **E.** abdominal fat plug grafts under white light and **F.** under blue light showing no fluorescence. Asterisk, sphenoid intersinus septum; X, herniated soft tissue; Y, abdominal fat graft; S, superior; I, inferior.

mimics the role of commercially available, blue light filter systems that are made for specific endoscopes or light sources.

Our choice of material was a limitation of this study. Since the commercially available face shield was made of acetate, it could only tolerate a maximum of 2 minutes before the acetate circles softened and became non-functional. Future studies may explore the use of a more heat-resistant type of plastic and application in more cases.

Meanwhile, based on our single-patient experience, our makeshift blue light filter made from readily available materials may be useful for endoscopic identification of CSF leaks using fluorescein in a low- to middle-income country setting like ours.

REFERENCES

1. Bohnen A, Louie CE, Domingo RA, de Biase G, Donaldson AM, Olomu OU, Boahene K, Quinones-Hinojosa A. Management of cerebrospinal fluid leaks. In: Quinones-Hinojosa A, editor. Schmidek and Sweet: Operative neurosurgical techniques, 7th edition. Philadelphia: Saunders; 2022. p. 1024-1036.
2. Ali ZS, Ma TS, Yan CH, Adappa ND, Palmer JN, Grady NS. Traumatic cerebrospinal fluid fistulas. In: Winn H, editor. Youmans and Winn neurological surgery, 7th Ed. Philadelphia: Elsevier; 2017. p. 2980-2987.
3. Ziu M, Savage JG, Jimenez DF. Diagnosis and treatment of cerebrospinal fluid rhinorrhea following accidental traumatic anterior skull base fractures. *Neurosurg Focus.* 2012 Jun; 32(6):E3. DOI: 10.3171/2012.4.FOCUS1244; PubMed PMID: 22655692.
4. Jefferson A, Reilly G. Fractures of the floor of the anterior cranial fossa. The selection of patients for dural repair. *Br J Surg.* 1972 Aug; 59(8):585-92. DOI: 10.1002/bjs.1800590802; PubMed PMID: 5069195.
5. Daudia A, Biswas D, Jones NS. Risk of meningitis with cerebrospinal fluid rhinorrhea. *Ann Otol Rhinol Laryngol.* 2007 Dec; 116(12):902-5. DOI: 10.1177/000348940711601206; PubMed PMID: 18217509.
6. Felisati G, Bianchi A, Lozza P, Portaleone S. Italian multicenter study on intrathecal fluorescein for craniosinusal fistulae. *Acta Otorhinolaryngol Ital*. 2008 Aug 28(4): 159-163.
7. Nagaya T, Nakamura Y, Choyke P, Kobayashi H. Current and new fluorescent probes for fluorescence-guided surgery. In: Hoffman RM, Bouvet M, editors. Strategies for curative fluorescence-guided surgery of cancer, New York: Elsevier; 2020. p. 75-114.
8. Wolfe R. Fluorescein angiography basic science and engineering. *Ophthalmology.* 1986 Dec; 93(12):1617-20. DOI: 10.1016/s0161-6420(86)33521-8; PubMed PMID: 3808620.
9. Ramalingam N, Nair NP, Saxena SK, Hegde JS. Role of blue-green light filter in detecting a spontaneous cerebrospinal fluid rhinorrhea in an unusual site. *Clin Rhinol An Int J.* 2018 May; 11(2 and 3):52-54. DOI: 10.5005/jp-journals-10013-1344.