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Endoscope Image Capture System with Mirrorless Camera

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Abstract

Modern endoscopic surgery relies on capturing high fidelity images for a multitude of purposes. One method of capturing images involves incorporating infrared and 4 k resolution video in the image capture system. However, the price of such whole image capture systems remains expensive and potentially cost prohibitive for some practitioners. A major need exists for less expensive alternatives. Herein, we introduce a method of using a mirrorless camera for the purposes of an endoscope capture device. This system comprises components that are all readily commercially available. Sample pictures taken by this system are provided and the potential function of mirrorless camera is explored. This image capture system provides reasonable quality images, should be more reasonably affordable and easily implementable in variety of practices, and will help decrease the barriers to producing research in the area of endoscopic surgery.

Keywords
- endoscopy
- image acquisition
- skull base

Introduction

Endoscopic approaches and techniques have been widely used in otolaryngology and neurosurgical approaches to the skull base for the past 20 years. One aspect of the endoscopic (evaluation and surgical) approach is the ability to capture high fidelity images of the operation, for both clinical purposes as well as academic applications. Most commonly, the endoscopic display allows image capture, which is designed by the manufacturer, and is the first choice for most clinicians. However, frequently older applications require transporting the video to the image capture hardware using a S-video port that does not allow picture taking or video recording function.[1] It is possible to upgrade this system using a dedicated digital camera system from the manufacturer, however, costs remain expensive. We explored whether a commercially available digital camera could be used as the image capture device for endoscopy.

In earlier literature, the application of digital single lens reflex (DSLR) to endoscopic photography was reported,[2] but the specific adapter ring between the camera and endoscope is expensive and time consuming. In addition, the heavy body of the DSLR camera limits its application. Thus, there is a need for lighter digital cameras in digital endoscopic photography, and several commercially available compact digital cameras (cDC) were also tested for endoscopic photography.[3] Such a solution is an inexpensive method capturing high quality images, but its viability is controversial. For example, recent literature has highlighted how the connection between the endoscope and the camera remains a problem.[4]

Another disadvantage of cDC is its autofocus system. During the endoscopic surgery or physical examination, several targets often appeared in the endoscopic vision field at different focus distance. Most cDC with unchangeable lens camera only provides the auto focus function, and auto-focus program would adjust the lens distance to the average distance of these

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targets. However, normally only one of the targets has the priority to be taken. Therefore, a digital camera, with a manual focus function is required.

We report our application of the Sony mirrorless camera, an extender, the rigid endoscope, and a connection with handset coupler (for focus) in the anatomy laboratory.

Materials and Methods

A 30 degree rigid endoscope (Stryker) was utilized. The Xenon digital light source (Stryker) was connected to the rigid endoscope as light resource. The coupler handset (Stryker) was used and provided C-mount for connection to the endoscope. The a6000 mirrorless camera (Sony Company) was used. A C-Nex mount adapter was connected the mirrorless camera with the coupler. A 5X extender with C-mount on both sides was placed between coupler and the adapter.

The a6000 was adjusted to the manual focus mode, which allowed for endoscopy usage. The Ap. protocol was utilized, the ISO 100 was used, and shutter time was adjusted to match the light resource. After white balance adjustment, the pictures were taken on formalin fixed cadaveric head.

Results

The camera fit the endoscope well with these devices. We used this set up to take high quality photographs from the endoscope with manual focus. ►**Fig. 1** shows the combination of the camera, adapter, extender, and the coupler to the rigid endoscope. ►**Fig. 2** shows a typical picture taken with the above apparatus along with endoscope. ►**Fig. 3** shows a picture first taken with the standard image acquisition system (**A**), and then with the mirrorless system described above (**B**), which was modified in image processing programs in (**C**) and (**D**). In addition, ►**Fig. 4** shows traditional photos (**A**), and photos taken with the mirrorless system (**B**) side by side. ►**Table 1** shows the flange focal distance between C mount and NX mount. This adapter not only provides the physical connection between coupler and camera, it also provides the information on the possible application of the different brands of mirrorless camera for endoscopic photography.

Fig. 1 Digital endoscopic equipment (from right to left): a6000 mirrorless camera (Sony Inc.), C-Nex mount adapter, 5X extender and the coupler (Stryker).

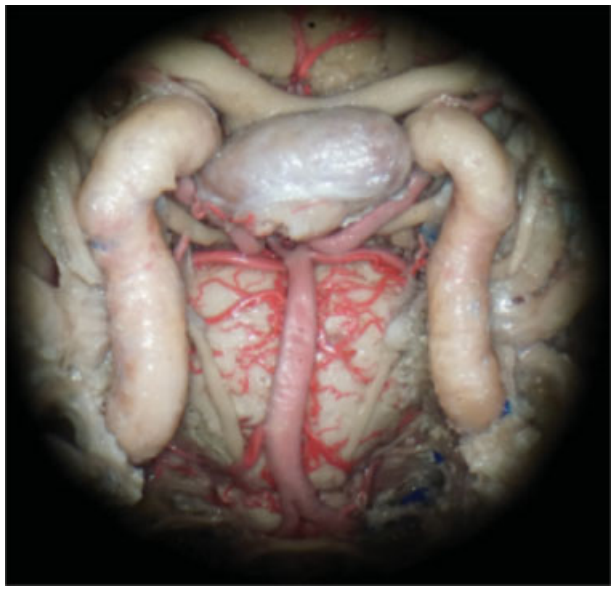

Fig. 2 Picture taken from the mirrorless camera is shown.

Discussion

This study provides a method of connecting the functionality of modern digital microscope to a rigid endoscope.

The need to connect high quality digital camera to endoscopic systems for the purpose of recording anatomical images is not new, and has been noted by several other groups.[1–4] Notably, Barr, 2009 used the cap of a plastic water bottle to connect a digital camera to a rigid endoscope with very good results.[4] Here, we use a similar "home-made" connection system, with the following advancements: (1) All the materials in our system can be purchased in an itemized fashion, from commercially available sources. (2) The entire connection system, apart from the camera, is able to undergo sterilization. This last advancement will be particularly useful if this technology is to be taken into either an examination or an operating room. The total cost of coupler, adapter, and extender is less than $100, and could be easily bought online.

More generally, this new system, composed of a rigid endoscope with coupler, extender, and adapter, was used to take high quality pictures. Another advancement of the current work is that, although DSLR and other kinds of digital cameras have been reported on endoscopic image capturing, no mirrorless camera has been attached to a rigid endoscope before.

Of note, the focusing distance of our coupler is 24 mm. If the mirrorless camera were attached to the coupler directly, it would result in pictures with very small visual field. Thus, we added a 5X extender between the coupler and the camera to enlarge the visual field. Also, the pictures taken by mirrorless camera do not have a clear border as compared with other proprietary systems (Stryker endoscopic system in this manuscript). Since the optical source determines the visual field by rigid endoscope, we believe the mirrorless camera preserves most optical information in the center.

Since the a6000 has the ability to couple with the 4K video recording of the rigid endoscope, we believe images from the

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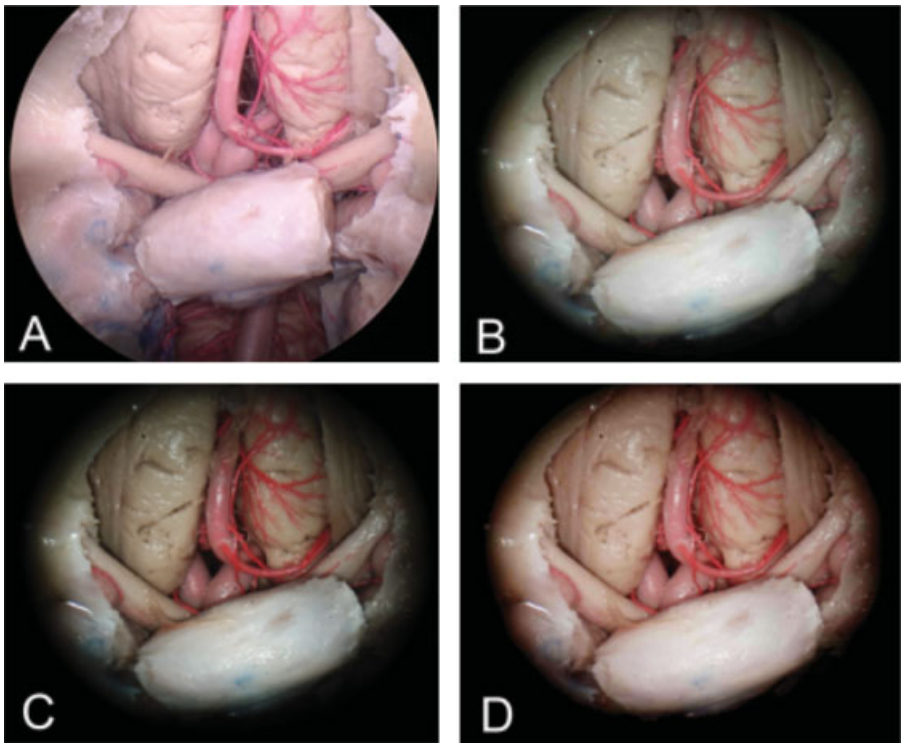

Fig. 3 (**A**) Image skull base acquired with Stryker 1488. (**B**) image acquired with Sony A6000 raw photo. (**C**) image modified post acquisition with color adjustment. (**D**) second attempt of modification adjusting contrast and enhancing red color.

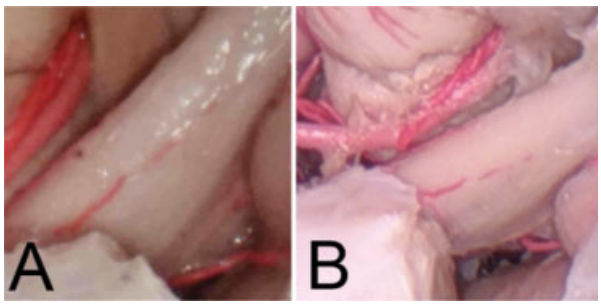

Fig. 4 Blowup. (**A**) a6000 Sony camera system. (**B**)1488 Stryker camera. Enlargement of the photo reveals clear picture is comparable.

Table1 Flange focal distance compared with C mount

	Flange focal distance
C mount	17. 526 mm
Nikon 1	17.00 mm
Fuji X	17.70 mm
Canon's EF-M	18 mm
Sony's E mount	18 mm
Panasonic and Olympus Micro 3/4	19.25 mm
Samsung NX	25.8 mm

endoscope should be acquired from this camera. Another interesting thing is most of the modern mirrorless camera could transport the picture via WIFI signal. If the rigid endoscope is attached with handset light resource, then the digital endoscopic picture system could be a totally wireless system.

Conclusion

The described mirrorless camera system allows for a reasonably affordable and highly functional method of capturing endoscopic images similar to potentially cost prohibitive systems that are commonly utilized in sinonasal evaluation and surgery. The potential usage for education and clinical applications should be further explored.

Financial Disclosures
The authors declare no competing financial interests

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