Original Article

Converting a conventional wired-halogen illuminated indirect ophthalmoscope to a wireless-light emitting diode illuminated indirect ophthalmoscope in less than 1000/- rupees

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Aim: To report the "do it yourself" method of converting an existing wired-halogen indirect ophthalmoscope (IO) to a wireless-light emitting diode (LED) IO and report the preferences of the patients and the ophthalmologists. **Subjects and Methods:** In this prospective observational study, a conventional IO was converted to wireless-LED IO using easily available, affordable electrical components. Conventional and the converted IO were then used to perform photo-stress test and take the feedback of subjects and the ophthalmologists regarding its handling and illumination characteristics. **Results:** The cost of conversion to wireless-LED was 815/- rupees. Twenty-nine subjects, mean age 34.3 ± 10 years with normal eyes were recruited in the study. Between the two illumination systems, there was no statistical difference in the magnitude of the visual acuity loss and the time to recovery of acuity and the bleached vision on photo-stress test, although the visual recovery was clinically faster with LED illumination. The heat sensation was more with halogen illumination than the LED (P = 0.009). The ophthalmologists rated wireless-LED IO higher than wired-halogen IO on the handling, examination comfort, patient's visual comfort and quality of the image. Twenty-two (81%) ophthalmologists wanted to change over to wireless-LED IO. **Conclusions:** Converting to wireless-LED IO is easy, cost-effective and preferred over a wired-halogen indirect ophthalmoscope.

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An indirect ophthalmoscope (IO) is an indispensable instrument universally used by the ophthalmologists to perform peripheral retinal evaluation. The conventional/older IOs were illuminated with a halogen bulb and required a transformer with a long cable that compromised on the portability of the instrument. With newer illumination methods using a light emitting diode (LED) and a wireless electrical supply, the newer IOs [Table 1] have become more portable and eco-friendly (more energy efficient along with lower heat emission). However, the wireless-LED IOs are priced considerably higher than the wired-halogen ones and many older versions are still in perfectly fine condition for a daily and rigorous clinical usage.

In this study, we present a cost-effective method to convert a wired-halogen IO to a wireless-LED IO and present a feedback of the patients and the ophthalmologists using both the types of illumination system in the same model of IO.

Subjects and Methods

Two binocular IOs (model AAIO 7, Appasamy Associates, Chennai, India) were used for the study. One was converted into wireless-LED system in the following manner.

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The halogen bulb with it power supply was first removed from the head mount and discarded. The LED illumination was made in the following manner.

A 3 W white LED bulb was glued to a standard printed circuit board (PCB) and mounted on an aluminum heat sink [Fig. 1]. The entire assembly was then mounted in the illumination housing of the IO.

A rechargeable battery pack was then made using battery, battery case, potentiometer, external knob, an on/off switch, red LED, resistor and a charging port connected with each other as shown in the circuit diagram [Fig. 2].

The detailed description of the components, the place of its availability and cost per piece is mentioned in Table 2.

The power pack [Fig. 3] was then mounted on the headband [Fig. 4] and connected to the PCB of the illumination system.

The rechargeable battery was charged for 6 h and the wireless-LED IO was commissioned in to use.

Twenty-nine adult subjects with normal eyes underwent an eye examination using the wireless-LED IO in the right eye followed by wired-halogen IO in the left eye. The illumination level used for each examination was kept equal using a light meter (HTC Luxmeter LX-101A).

A photo-stress test was performed prior to the above mentioned examination using illumination level of 200 lux and 10 s exposure; first with wireless-LED in front of the right eye and then wired-halogen LED in front of the left eye after a gap of 5 min. The loss in best corrected visual acuity after 10 s, time to

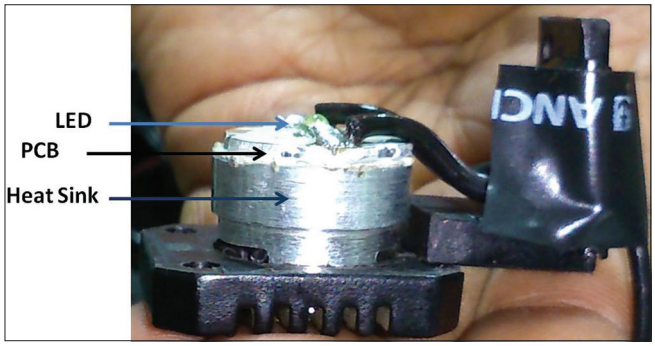

Figure 1: Shows the illumination assembly

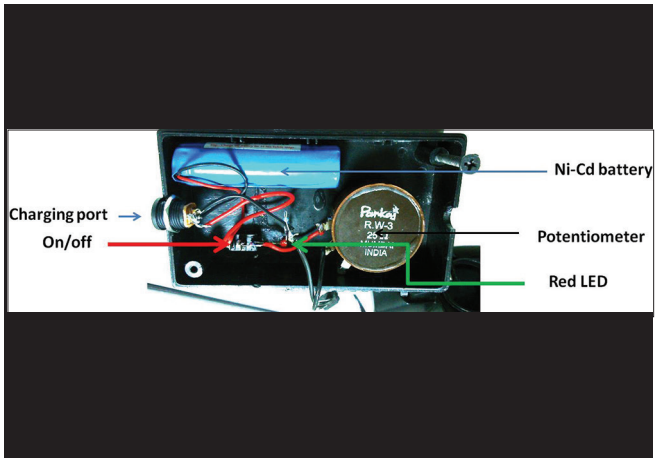

Figure 3: The inside view of the battery pack

recovery to the pretest best corrected visual acuity and complete recovery of light-induced bleaching were noted down.

In a different clinical setting, the IOs were given to 27 ophthalmologists to provide their feedback on the predefined parameter.

The data for wireless-LED IO were compared with wired-halogen IO using a two-tailed paired *t*-test.

Before recruiting the subjects, an oral informed consent was taken. Most subjects were working as the clinical/paraclinical/nonmedical staff in our organization.

Results

The cost of conversion was 815/- rupees. We included 29 subjects with a mean age 34.3 ± 10 years of which 19 were females. There was no statistical difference in the visual acuity loss and the subsequent recovery of acuity and the bleached vision between the two illumination systems although the visual recovery was clinically faster with LED illumination [Table 3]. The subjects clearly felt the heat sensation more with halogen illumination than the LED [Table 4].

We included 27 ophthalmologists (6 residents, 2 retinologists and 19 pediatric ophthalmologists) with a mean age 35 ± 6 years of which 11 were females. All the handling and illumination parameters were graded little better on LED IO versus halogen IO [Table 4]. Majority ophthalmologists preferred to change over to wireless-LED IO [Table 5].

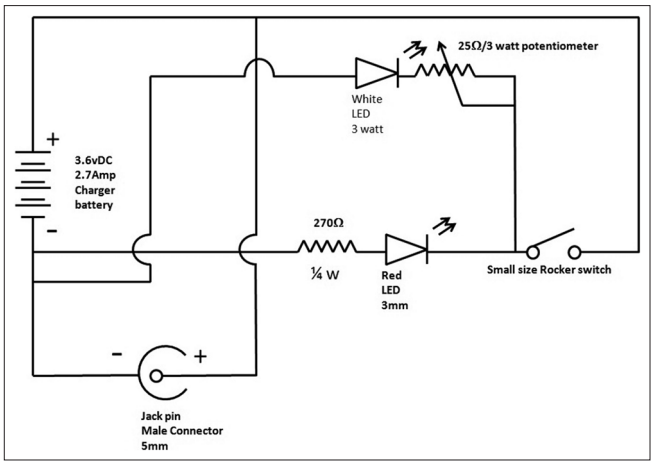

Figure 2: Circuit diagram for the battery pack

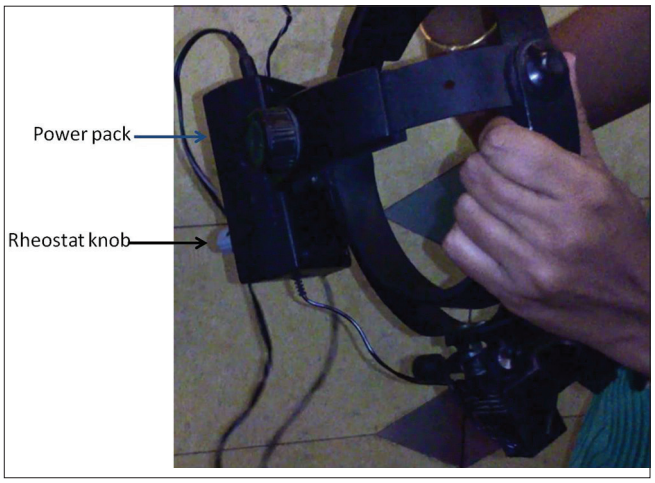

Figure 4: The battery pack mounted on the head band and connected to the charging adapter

Table 1: List of modern wireless-LED ophthalmoscope models and their manufacturer's details that are currently available in India

Model	Manufacturer	Make
Omega 500	Heine Optotechnik, Kientalstrasse 7, D-82211 Herrsching, Germany	Germany
Vantage plus	Keeler Ltd., Windsor, Berkshire, SL4, 4AA, UK	UK
AAIO-wireless	Appasamy Associates, First Street, Arumbakkam, 20, SBI Officers' Colony, Chennai (Madras)-600 106, Tamil Nadu, India	India
WIO	Two M Ophthotronics, Shop No.-13, Dalvi Plaza, Om Nagar Chowk, J.B. Nagar, Andheri (East), Mumbai-400 059, India	India

LED: Light emitting diode

Discussion

An IO is a frequently used instrument by the ophthalmologists all over the world. The newer models from various ophthalmic instrument manufacturers are available with the option of wireless and LED illumination. However, those models

Table 2: The electrical components for making a wireless-LED indirect ophthalmoscope

Item	Description	Availability	Cost in Indian rupees
LED	3 W (white/day yellow/yellow)	Precious Electronics, Mumbai	60
Heat sink	Aluminum	Manufacturing on CNC Machine	65
PCB	For the LED power supply	PCB (Shogini, Pune)	45
coupling glue	White standard heat sing glue	Precious Electronics	05
Battery	Rechargeable, nickel cadmium, 3.6 V, 2.7 A	Gala Electronics, Mumbai	270
Battery case	Plastic case for housing the power pack	Chandratronics, Mumbai	70
Potentiometer	3 W, 25 Ω	Madhu Subtronics/VRM Sales, Mumbai	86
External knob	Plastic illumination control knob	Madhu Subtronics/VRM Sales, Mumbai	12
On-off switch	3 A/6 A	Madhu Subtronics/VRM Sales, Mumbai	26
LED	Red LED (indicator light)	Madhu Subtronics/Ramesh Electronics, Mumbai	02
Resistor	270 Ω	Ramesh Electronics, Mumbai	1.20
Charging port	3 mm, male battery charging port (max. brand)	Champion Rubber, Mumbai	57
Charger	3.6 V battery compatible travel adapter	Ramesh Electronics, Mumbai	115
Total cost			815

LED: Light emitting diode, PCB: Printed circuit board

Table 3: The results of the photo stress test-LED IO versus halogen IO (*n*=29)

Parameter assessed	Wired-halogen IO	Wireless-LED IO	Paired *t*-test (*P*)
Number of lines lost on photostress test	7.4±2.5	7.3±2.1	0.9
Time to recovery of best corrected visual acuity	85±36 s	66±60 s	0.7
Time to recovery to normal vision (complete recovery from bleached vision)	151±75 s	89±47 s	0.9

LED: Light emitting diode, IO: Indirect ophthalmoscope

Table 4: Feedback of the patients (*n*=29)

Parameter assessed*	Wired-halogen IO	Wireless-LED IO	Paired *t*-test (*P*)
Heat sensation	0.4	0.1	0.009
Burning sensation	0.1	0.03	0.41
Photophobia	0.345	0.345	1.0
Number of subjects who preferred one over the other	9	16	

*0: No sensation, 1: Little sensation, 2: Significant sensation. LED: Light emitting diode, IO: Indirect ophthalmoscope

Table 5: Feedback of the ophthalmologists (*n*=27)

Parameter assessed	Score*
Visual comfort in examining a patient	+0.8
Comfort in handling the instrument and moving around the patient during the examination	+0.9
Comfort to the patient while examined	+0.6
Resolution/clarity of the image and posterior segment structures	+0.7
Would you like to change to the IO	22 yes, 2 no, 3 not sure
Any other remarks	6 would prefer yellow LED, 2 advised reduction of the weight of the battery pack

*0: No difference, +1: Little better, +2: Significant better, –1: Little worse, –2: Significant worse. IO: Indirect ophthalmoscope, LED: Light emitting diode

are significantly (2–3 times) higher priced. They offer an advantage of excellent portability and the advantages of a LED illumination. In comparison to halogen, LED consumes 1/4th electricity, life is around 100 times longer, and the illumination character is closer to natural sun light albeit the cost is higher.

In the present study, wireless-LED IO was made using easily available and cheap electrical components [Table 2]. The cost of the LED was 60/- rupees only and that of all the components together was 815/- rupees. Although, such a conversion can be done by anyone with the basic knowledge of science of electrical engineering, we took help of the professional who were already in the business of medical instrument manufacturing. It makes sense to take their help as they would have an easy access to these electrical components and used to purchase such components in bulk.

We are using the modified wireless-LED IO since 10 months in a high volume pediatric ophthalmology practice (with considerable movement for retinopathy of prematurity screening) without any problems. The charging of the instrument is needed once in every 4–6 months. The life of the Ni-Cd rechargeable battery is estimated to be 1000 charging cycle.

When the LED demonstrates a minimal flicker at higher illumination level, it is an indication of the time for battery recharge. It usually takes 4–6 h for the battery to be recharged fully. Although the manufacturers suggest that it is advisable to recharge the battery after it is completely discharged, it is not necessary. Nevertheless, if the battery malfunctions/is discharged when an ophthalmologist needs to use the instrument, the IO would continue to function with direct electrical supply using any travel adapter.

There are reports of retinal/macular toxicity (photo-thermal/photo-chemical/photo-radicals injury) following excessive

exposure to microscope/endoscope light *in vivo* (rabbit model) and *in vitro* (retinal pigment epithelium).[1-5] However, there are no comparisons available for halogen with LED IO in human. In this study, we found LED illumination comparable (if not superior) to the halogen bulb in terms of photo-stress vision loss and recovery and comfort to the patient. The sensation of heat was more due to higher light energy in the halogen light.

All the ophthalmologists were used to yellow light and preferred a yellow LED instead of a white LED, especially for the evaluation of the disc pallor.

Conclusion

Wireless-LED IO was found to be more portable and its LED illumination system was preferred by the patients as well as the ophthalmologists. With a simple knowledge of electrical engineering, using easily available electrical components from the market, a conventional IO can be converted to a wireless-LED IO in <1000/- rupees.

Acknowledgments

Mr. Chetan Shah, Akshaya Instruments, 26/2 Rocky Industrial Estate, I B Patel Road, Goregaon (East), Mumbai - 400 063, Maharashtra, India.

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