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## SCIENTIFIC ARTICLE

# Accuracy of a smartphone to test laryngoscope's light and an audit to our laryngoscopes using an ISO standard



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### KEYWORDS

Laryngoscope;  
Laryngoscopy;  
Light;  
Accuracy;  
Smartphone;  
Lux meter

### Abstract

**Background and objectives:** Laryngoscope is a key tool in anesthetic practice. Direct laryngoscopy is a crucial moment and inadequate laryngoscope's light can lead to catastrophic consequences. From our experience laryngoscope's light is assessed in a subjective manner and we believe a more precise evaluation should be used. Our objective is to compare the accuracy of a smartphone compared to a lux meter. Secondly we audited our Operating Room laryngoscopes.

**Methods:** We designed a pragmatic study, using as primary outcome the accuracy of a smartphone compared to the lux meter. Further we audited with both the lux meter and the smartphone all laryngoscopes and blades ready to use in our Operating Rooms, using the International Standard form the International Organization for Standardization.

**Results:** For primary outcome we found no significant difference between devices. Our audit showed that only 2 in 48 laryngoscopes complied with the ISO norm. When comparing the measurements between the lux meter and the smartphone we found no significant difference.

**Discussion:** Ideally every laryngoscope should perform as required. We believe all laryngoscopes should have a practical but reliable and objective test prior to its utilization. Our results suggest the smartphone was accurate enough to be used as a lux meter to test laryngoscope's light. Audit results showing only 4% comply with the ISO standard are consistent with other studies.

**Conclusion:** The tested smartphone has enough accuracy to perform light measurement in laryngoscopes. We believe this is a step further to perform an objective routine check to laryngoscope's light.

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**PALAVRAS-CHAVE**

Laringoscópio;  
Laringoscopia;  
Luz;  
Precisão;  
*Smartphone*;  
Luxímetro

## Precisão de um *smartphone* para testar a luz de laringoscópio e uma auditoria de nossos laringoscópios usando as normas da ISO

**Resumo**

*Justificativa e objetivo:* O laringoscópio é uma ferramenta essencial na prática anestésica. A laringoscopia direta é um momento crucial e uma luz inadequada do laringoscópio pode levar a consequências catastróficas. De acordo com nossas pesquisas, a luz do laringoscópio é avaliada de forma subjetiva e acreditamos que uma avaliação mais precisa deve ser feita. Nosso objetivo foi comparar a precisão de um *smartphone* com a de um luxímetro. Depois, fizemos uma auditoria de nossos laringoscópios em sala de operação.

*Métodos:* Estudo pragmático usando como desfecho primário a precisão de um *smartphone* em comparação com a de um luxímetro. Subsequentemente, fizemos uma auditoria tanto com o luxímetro quanto com o *smartphone* de todos os laringoscópios e lâminas prontos para uso em nossas salas de cirurgia, usando as normas da International Organization for Standardization (ISO).

*Resultados:* Para o desfecho primário não encontramos diferença significativa entre os dispositivos. Nossa auditoria mostrou que apenas dois em 48 laringoscópios satisfizeram as normas da ISO. Ao comparar as mensurações entre o luxímetro e o *smartphone*, não encontramos diferença significativa.

*Discussão:* Idealmente, todos os laringoscópios deviam funcionar conforme previsto. Acreditamos que todos os laringoscópios devem ser submetidos a um teste prático, mas confiável e objetivo, antes de serem usados. Nossos resultados sugerem que o *smartphone* foi preciso o suficiente para ser usado como um luxímetro para testar a luz do laringoscópio. Os resultados da auditoria mostrando apenas 4% de conformidade com as normas da ISO corroboram os de outros estudos.

*Conclusão:* O *smartphone* testado tem precisão suficiente para fazer a medição de luz em laringoscópios. Acreditamos que esse é um passo adiante na execução de uma verificação objetiva de rotina da luz do laringoscópio.

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**Background and objectives**

Laryngoscope is a key tool in anesthetic practice. Direct laryngoscopy is a crucial moment in the induction phase of anesthesia and inadequate laryngoscope's light can lead to catastrophic consequences. From our experience laryngoscope's light is assessed worldwide in a subjective manner and we believe a more precise evaluation should be used. There are a few studies addressing laryngoscope's light and the results show insufficient light in most of the tested laryngoscopes.<sup>1,2</sup>

In a small informal survey in our Anesthesiology and Operating Room departments we found laryngoscope's light as a frequent complain. Our objective is to compare the accuracy of a smartphone compared to a lux meter and secondly we audited our Operating Room laryngoscopes. Our hypothesis states that a smartphone has accuracy similar to a lux meter. Further, we also audited all laryngoscopes ready to use in all Operating Rooms.

**Methods**

We designed a pragmatic study to test the accuracy of a smartphone measuring illuminance using a lux meter as a

reference. Secondly we audited our ready-to-use Operating Room laryngoscopes.

Primary outcome was the accuracy of the smartphone compared to the lux meter. The null hypothesis was no difference between measurements from the smartphone compared to the lux meter.

Before performing the study, institutional authorization was granted. Two different protocols were made, one to test the accuracy of the smartphone compared to the lux meter, and other to audit the laryngoscopes.

To test the accuracy of the smartphone measuring illuminance we used as light source a white fluorescent lamp (OSRAM Licht AG<sup>®</sup>) with a dimmer to produce different light intensities. The smartphone used to test for accuracy was a Motorola<sup>®</sup> Moto G XT1068 and the control was a lux meter (HDE<sup>®</sup> LX-1010B). Motorola was contacted and said we should expect 80% accuracy in a range from 5 to 10,000 lux, while the lux meter advertises 95% accuracy in a range of 0–50,000.

Since the cut-off of the ISO standard is 500 lux<sup>3</sup> we arbitrarily set a total of 20 light intensities from 50 to 1000 lux in increases of 50 lux. To set each light intensity we dimmed the lamp in a dark room and measured the illuminance with the lux meter until we got the expected value. This measurement was performed in a room with no external light other than the light lamp and with the lux meter sensor

20 mm away from it. After setting the desirable light intensity using the dimming and controlling it with the lux meter, the smartphone's light sensor (position previously known from technical specifications) was placed in the same place as the lux meter sensor and illuminance value was measured using a specific application. Once opened the smartphone application, it continually reads the raw values retrieved from the light sensor of the smartphone and output them in the smartphone display. To reduce potential bias of using and unknown coded app to measure light from the smartphone sensor we programed the Android™ application and published its source code online.<sup>4</sup>

We repeated the smartphone measurement three times for each light intensity tested (using the lux meter as a control) and then calculated the mean value.

Results comparing the smartphone accuracy in the specified light intensities were performed with paired sample *t*-test using a *p*-value of 0.05, with IBM® SPSS® Statistics 22.

To audit our laryngoscopes we used as reference the international standard form the International Organization for Standardization (ISO 7376:2009) which specifies minimum illuminance of 500 lux after 10 min for hook-on type laryngoscopes measured 20mm from laryngoscope's tip.<sup>3</sup>

To perform our audit we constructed a device capable to hold the laryngoscope standstill in such a manner that the tip of laryngoscope's light was 20 mm from the lux meter sensor as required by the ISO standard. Our device was also able to protect the lux meter sensor from external light even with the measurements performed in a dark room. To perform the audit we measured illuminance using the same lux meter (HDE® LX-1010B).

All the measurements were performed in the same day and our sample was all ready-to-use laryngoscopes from 14 Operating Rooms. All the tested laryngoscopes were reusable, battery-operated and xenon bulb-in-handle, from Welch Allyn® or Heine® brands. Blades were hook-on MacIntosh type sizes 3–5. We performed a total of 48 tests, testing each ready-to-use combination of handle and blade in each Operating Room, in a total of 48 tests performed.

Measurements were made placing the laryngoscope (handle and blade) in the device built and recorded the lux meter value on tenth minute after turned on. Data from the audit was analyzed using IBM® SPSS® Statistics 22.

## Results

For the primary outcome, we calculated the mean of the 3 measurements made with the smartphone and compared with the value from the lux meter. We found no significant difference between devices;  $t(19) = -1.489$ ,  $p > 0.05$ . The mean difference between measurements was  $-0.35$  lux with a standard deviation of 1.05118 lux. Results are represented in Fig. 1.

In the audition made only 2 in 48 laryngoscopes showed a minimum illuminance of 500 lux (Fig. 2). Mean illuminance was 212.48 lux with a standard deviation of 114.810 lux. Interquartile ranges were  $Q1 = 112.25$ ,  $Q2 = 189.00$  and  $Q3 = 300.50$  lux.

When comparing the measurements between the lux meter and the smartphone (Fig. 3) we found no significant

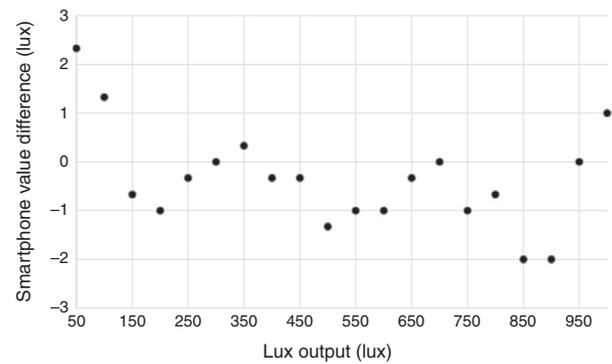


Figure 1 Smartphone values difference to control.

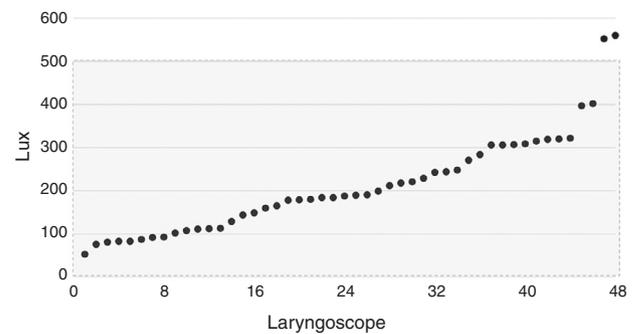


Figure 2 Laryngoscope's illuminance.

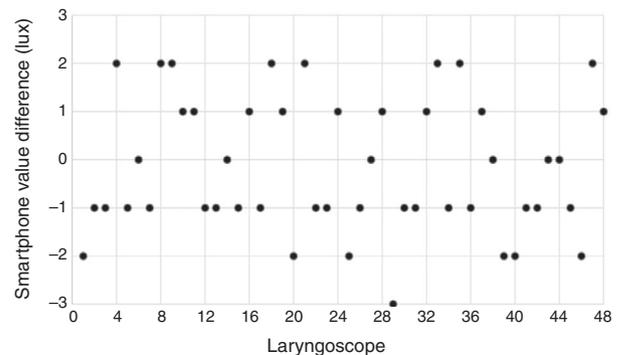


Figure 3 Smartphone value's difference to laryngoscopes.

difference;  $t(47) = -0.831$ ,  $p > 0.05$  with a mean difference of  $-0.167$  lux and a standard deviation of 1.389 lux.

## Discussion

Laryngoscopy is one of the most frequent and important techniques performed by the anesthesiologist in his daily practice and ideally every laryngoscope should perform as required. We believe every laryngoscope should have a practical but reliable and objective test prior to its utilization. Our results suggest that smartphones can be reliably to test laryngoscopes' illuminance.

In our tests, we found a mean difference between the lux meter and the smartphone less than 1 lux. As the main goal is to know if the light has a minimum output of 500 lux, we believe our smartphone was capable of perform that task accurately.

Our audit results showing only 4% comply with the ISO standard are consistent with other studies.<sup>1,2</sup> We believe regular audits should be made and attitudes to fix that situation. In our study we did not address what was the problem in each laryngoscope.

Although Motorola® said we should expect an accuracy of 80% in the range from 5 to 10,000 we believe this is a conservative value and we found our smartphone much more accurate.

We identified some limitations. Not all smartphones have a light sensor and even those with it, their accuracy can be variable and its position can be difficult to find. Each smartphone should be tested for accuracy before being used. There are different apps to measure light values, and to reduce this bias we designed and published its source code. The used lux meter was the best possible however we are aware that there are much more precise lux meters, although we believe our lux meter was precise enough. Measurements from 50 to 1000 lux in intervals of 50 lux were arbitrarily set. As our audit was pragmatic to all ready to use laryngoscopes, in some cases the same laryngoscope was tested with two different blades.

## Conclusions

We propose that a smartphone can be accurate enough to classify laryngoscope's light as adequate to perform laryngoscopy. Our conclusion is that the tested smartphone has enough accuracy to perform light measurement in laryngoscopes light. Since each smartphone can have a different light sensor this conclusion cannot be generalized.

In the future more studies are needed to test other devices like smartphones and to understand if perform a laryngoscope light test before each use can have a positive influence in the laryngoscopy and outcome of the patient. There is also a need of studies to understand the source of the problem to laryngoscopes do not comply with the ISO norm.

We believe this could be a step further in performing an objective routine check to laryngoscope's light.

## Conflicts of interest

The authors declare no conflicts of interest.

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