DOI:
10.1016/j.ijsu.2016.11.013

Document Version
Peer reviewed version

Citation for published version (APA):
Iqbal, M. H., Aydin, A., Lowdon, A., Ahmed, H. I., Muir, G. H., Khan, M. S., Dasgupta, P., & Ahmed, K. (2016). The effectiveness of Google GLASS as a vital signs monitor in surgery: A simulation study. *International Journal Of Surgery*, *36*(Pt A), 293-297. https://doi.org/10.1016/j.ijsu.2016.11.013

Accepted Manuscript

The Effectiveness of Google GLASS as a Vital Signs Monitor in Surgery: A Simulation Study

Mohammed Husnain Iqbal, BSc (Hons), Abdullatif Aydin, BSc (Hons), MBBS, Alexandra Lowdon, BSc (Hons), Hamza Ibn Ahmed, BSc (Hons), Gordon H. Muir, FRCS (Urol), FEBU, Muhammad Shamim Khan, OBE, FRCS (Urol), FEBU, Prokar Dasgupta, MSc, MD, FRCS (Urol), FEBU, Kamran Ahmed, MBBS, MRCS, PhD

PII: S1743-9191(16)31022-6

DOI: 10.1016/j.ijsu.2016.11.013

Reference: IJSU 3203

To appear in: *International Journal of Surgery*

Received Date: 7 September 2016

Revised Date: 3 November 2016

Accepted Date: 4 November 2016

Please cite this article as: Iqbal MH, Aydin A, Lowdon A, Ahmed HI, Muir GH, Khan MS, Dasgupta P, Ahmed K, The Effectiveness of Google GLASS as a Vital Signs Monitor in Surgery: A Simulation Study, *International Journal of Surgery* (2016), doi: 10.1016/j.ijsu.2016.11.013.

The Effectiveness of Google GLASS as a Vital Signs Monitor in Surgery: A Simulation Study

Authors:

Mohammed Husnain Iqbal (1) BSc (Hons)

Abdullatif Aydin (1) BSc (Hons), MBBS

Alexandra Lowdon (1) BSc (Hons)

Hamza Ibn Ahmed (1) BSc (Hons)

Gordon H Muir (2) FRCS (Urol), FEBU

Muhammad Shamim Khan (1) OBE, FRCS (Urol), FEBU

Prokar Dasgupta (1) MSc, MD, FRCS (Urol), FEBU

Kamran Ahmed (1) MRCS, PhD

Affiliations:

(1) MRC Centre for Transplantation, King's College London

Department of Urology, Guy's and St. Thomas' NHS Foundation Trust

King's Health Partners, London, United Kingdom

(2) Department of Urology, King's College Hospital NHS Foundation Trust,

King's Health Partners, London, United Kingdom

Correspondence:

Kamran Ahmed MBBS, MRCS, PhD

NIHR Academic Clinical Lecturer

MRC Centre for Transplantation

Guy's Hospital, King's College London

London, UK

Ph: +44 (0)7939319670

Email: kamran.ahmed@kcl.ac.uk

ABSTRACT

Introduction: To assess the effectiveness of the Google GLASS as a vital signs monitor in a surgical setting and identify potential uses.

Methods: This prospective, observational and comparative study recruited novice (n=24), intermediate (n=8) and expert urologists (n=5). All candidates performed a procedure on the GreenLight Simulator within a simulated setting using a standard vital signs monitor and then the Google GLASS. The time taken to respond to abnormal vital signs during both sessions was recorded. A quantitative survey was used to assess the usability and acceptability of the Google GLASS surgery.

Results: The majority (84%) of participants responded quicker to abnormal signs with the Google GLASS compared to a standard monitor ($p = 0.0267$). The average simulation score during a standard-monitor and GLASS-session scored to be statistically insignificant ($p = 0.253$). All parameters of simulation were also similar in both sessions including average sweep speed ($p = 0.594$), average blood loss ($p = 0.761$) and average grams vaporised ($p = 0.102$).

Discussion: Surgical performance between both sessions was similar and not hampered by the use of Google GLASS. Furthermore, 81% of candidates stated the GLASS was comfortable to wear during the procedure.

Conclusion: This study has demonstrated that head-mounted displays such as the Google GLASS are potentially useful in surgery to aid patient care without hampering the surgeons view. It is hoped that the innovation and evolution of these devices triggers the potential future application of such devices within the medical field.

INTRODUCTION

With consumer demands on the increase for technological devices to become more innovative and hands-free, we are presented with the '*Google Glass'* (Google, Mountain View, California), a wearable device mounted on glasses, designed to display smartphone-like information on a screen whilst allowing users to remain hands-free. It has demonstrated usefulness in various fields including surgery [1, 2], electrocardiography (ECG) monitoring [3, 4] and as a teaching and training tool [5, 6].

A potential use of the Google GLASS is monitoring vital signs during surgical procedures. Although no specific study has been conducted into the use of the Google GLASS as a vital signs monitor, various studies have demonstrated positive results for the use of Google GLASS and other head-mounted displays to monitor various parameters such as ECG [3, 4]. The results of these studies indicate that the GLASS along with a zoom and pan software (VitalCom, VitalMedicals, California, USA) was non-inferior to interpreting ECGs on paper. This raises the idea that Google GLASS can potentially allow medical professionals to monitor several parameters of patient vital signs, during a surgical procedure.

This study aims to assess the feasibility and acceptability of the application of Google GLASS within a surgical setting. The primary aim of the study is to determine whether the Google GLASS increases the awareness of patient vital signs and whether such devices are intrusive or detrimental to the surgeon's direct or peripheral vision and technical performance.

SUBJECTS AND METHODS

Study Participants

This is a prospective, observational and comparative study, which recruited participants from various institutions in the United Kingdom (KCL, KCH, GSTT), who were divided into Novices (medical students; n=24), Intermediates (Urology Surgical Trainees; n=8) and Experts (Consultant Urologists; n=5).

Study Design Process

Novices performed a training session prior to monitored sessions, followed by a 20-minute laser prostatectomy on the previously validated GreenLight Simulator [7] (Boston Scientific, Marlborough, MA, USA) using a standard vital signs monitor, which was manipulated to represent events in surgery such as a falling blood pressure, oxygen saturations and other parameters. All deteriorations were manipulated to occur in the presence of the participant and with the times at which they occurred varying between sessions. This session was followed by another 20-minute session using the Google GLASS to monitor vital signs. Users were not provided with feedback between sessions. Intermediate and expert candidates performed the same procedure but within 10-minutes (Figure 1).

Sessions were conducted within a validated full immersion simulation surgical environment, with an anaesthetists and scrub nurse present to simulate scenarios [8, 9]. After completion of both sessions, subjects completed a quantitative survey which included basic demographics and previous experience, opinions on the Google GLASS and its usability within the surgical field.

Performance Evaluation

Time taken for participants to respond to abnormal vital signs in both scenarios were recorded. Following completion of the procedure, an instant performance evaluation report is generated by the simulator, to provide objective results. The overall score is based on task-specific metrics such as average sweep speed, amount vaporised, blood loss and anatomical structural damage. These parameters were recorded to determine the effect of the Google GLASS on surgical performance. Furthermore, the average heart rate of participants during both sessions was also recorded using the Polaris watch (Polar Electro, Warwick, UK).

Outcome Measures

The outcome measures of the study were (1) time taken to respond to change in vital signs, (2) effect of Google GLASS on technical performance, provided by the simulator, (3) effect of Google GLASS on non-technical performance, assessed by measuring average heart rate in both sessions, and (4) the acceptability and feasibility of using the Google GLASS during surgical procedures.

Statistical Analysis

Statistical analysis was performed using *GraphPad version 6.0* (Prism, La Jolla, California, USA). Comparison between novices, intermediate and expert candidates in standard monitor and Google GLASS sessions along with survey response were analyzed using the non-parametric Mann-Whitney U test. A p-value of <0.05 was considered statistically significant in both tests.

RESULTS

Demographics

This study recruited 37 participants, comprising of 24 Novices, 8 Intermediates and 5 Experts. Medical students from various London medical schools were recruited as novices. Intermediate group consisted of urology trainees and experts were consultants who had performed an average of 2000 cystoscopies and 900 laser prostatectomies and 825 average GreenLight prostatectomies.

Response Time to Change in Vital Signs

A significant proportion (84%) of participants responded to abnormal vital signs quicker when performing the simulated operation for the second time using the Google GLASS, with 100% of experts responding faster on the second operation. The average response time to abnormal vital signs with a standard vital signs monitor was 51.5 seconds (95% CI 41.8, 61.25) compared to 35.5 seconds (95% CI 24.9, 46.0) with the Google GLASS ($p=0.0267$). Figure 2A highlights the range of values that were obtained, for the standard monitor (Interquartile range [IQR], 13-107 s) compared to the GLASS (IQR 4-115 s). No false positives or false negatives were recorded during any of the scenarios.

Technical Performance

Overall global simulation score for novice (mean: 177), intermediate (mean: 314) and expert (mean: 420) participants were assessed (Figure 2B) demonstrating a statistically significant difference between novices and intermediates (p=0.0038) and novices and experts (p<0.0001). Global score comparison between intermediates and experts was not statistically significant (p=0.13). Sweeping is a vital parameter in performing a GL prostatectomy. During standard monitor sessions, participants had an overall higher sweeping speed (mean: 7.49 mm/sec) compared to the GLASS session (mean: 7.151 mm/sec; Figure 3). Furthermore, participants who found the GLASS distracting had higher blood loss during sessions when using it (Range: 0.3-25.7 mL) compared to using a standard monitor (Range: 0.4-19.0 mL). However, despite this, the mean blood loss was lower when using the GLASS (mean: 3.66), compared to a normal monitor (mean: 4.16). All parameters of simulation were also noted to be similar in both sessions including average sweep speed (p = 0.59), average blood loss (p = 0.76), average grams vaporised (p = 0.102) and average laser distance from the tissue (p = 0.55). A total of 45 injuries were identified during scenarios, with verumontanum injuries occurring the most (n = 36). Of these, 24 injuries occurred whilst wearing the GLASS compared to 12, when using a standard monitor.

Participant Heart Rate

Participants' heart rates (HR) were constant whilst using a standard monitor (Mean: 84 bpm [beats per minute]) and the Google GLASS (Mean: 80 bpm). Subjects further reported no anxiety or nervousness responses on the survey.

Acceptability & Feasibility

A significant majority of novices (79%), intermediates (75%) and experts (80%) agreed that the Google GLASS increased their awareness of vital signs whilst 71% of novices, 75% of intermediates and 100% of experts agreed that they would like to use the GLASS in another surgical procedure in the future. The majority of participants (75.7% [95% CI 58.8, 88.2]) agreed that the Google GLASS increased their awareness of vital signs compared to a standard vital signs monitor. When participants were asked to provide their opinion using the Google GLASS, 81% agreed the Google GLASS was comfortable to wear during the procedure, and 68% stated they would like to use the Google GLASS in this procedure again.

DISCUSSION

Advances in technology have revolutionised medicine; from simple wearable devices, targeted to aid patient fitness, to more complex devices such as the Google GLASS [10-12]. The use of head-mounted displays (HMDs) have previously been demonstrated within the medical field [13], but due to poor specifications and often obstruction of the peripheral vision, have failed to make a significant impact.

This study has investigated the use of the Google GLASS within surgery and whether such devices affect technical performance. The results show a statistically significant correlation (p=0.0267) between the use of Google GLASS and detection of deteriorating vital signs. Although monitoring of vital signs is primarily the responsibility of the anaesthetic team, surgeons are also concerned with such parameters. The use of this device can, in theory, allow surgeons to focus on the surgical site without having to discuss vital signs with anaesthetists or leaving the attention of the surgical field to refer to another monitor elsewhere within the operating room. Furthermore, such a device may also prove to be extremely useful by the anaesthetic team, ultimately contributing to patient safety.

Using the Google GLASS had no effect on technical skills, as reflected by the overall simulation score of all candidates between the two simulation scenarios in novices (p = 0.33), intermediates (p = 0.64) and experts (p = 0.64). Furthermore, there was no significant statistical difference between various parameters such as sweeping speed (p = 0.59), average blood loss (p = 0.76), average grams vaporised (p = 0.10) and average laser distance (p = 0.55). The average heart rate during both sessions was also similar (p = 0.77). The overall simulation score along with various parameters allows reasonable extrapolation to state that using the GLASS would not impact the surgeon's operative performance. As such, not only could the Google GLASS be used as a vital signs monitor, it could potentially be used for other purposes such as viewing imaging during surgery. Furthermore, it can also be used as a tele-mentoring device to teach and monitor surgeries across different countries. Other studies have also highlighted uses in the nursing field such as regular vital signs monitoring and early identification of patients at risk of potential deterioration [15].

The overall performance when using the Google GLASS, in comparison to the standard monitor, was higher in 62% of participants. This may be attributed to experience gained in the previous session. The mean simulation score for standard monitor sessions was 162 compared to 192 with the GLASS (p = 0.253) indicating surgical performance between both sessions was similar and statistically insignificant.

Despite all the advantages reported, there are also drawbacks with using the Google GLASS as a vital signs monitor. Participants who already wear glasses reported that it was uncomfortable to wear the GLASS over their regular spectacles. Furthermore, battery issues with the current GLASS means that it would require re-charging every 2-3 hours, making it impractical for use in its current form. Moreover, due to design limitations, the GLASS can only have the optical device in front of the right eye; users who are left handed reported significant discomfort with this design specification.

As with any study, there are limitations to the current study. Intermediate and expert candidates were only recruited for 10-minute simulation sessions due to time constraints. Hence, they were unable to complete a full prostatectomy procedure. Furthermore, as the GLASS sessions were after the standard monitor, we cannot rule out any learning curve in between sessions, it is also likely that individuals eased into sessions and hence felt more comfortable during the second half of the study.

Several areas of future work are possible; this study has demonstrated the use of using HMDs in surgery for vital signs monitoring. It would be interesting to repeat this study to obtain a full set of recordings of participants between using the Google GLASS and standard monitor in order to assess any difference in psychological ability or awareness of peripheral surroundings. Furthermore, to repeat the current study in a real operating room during surgical procedures would be a great addition, however ethical approval would be required. The Google GLASS has various potential to thrive within the medical field, as highlighted by survey response from experts in the current study. It has the potential to be used in medical education such as for tele-mentoring.

CONCLUSION

The Google GLASS is one of the first HMDs, which has the design specifications to allow use without obstructing direct and peripheral vision. As highlighted by this study, such a device can prove to be beneficial for use in the operating room such as increasing awareness of patient vital signs, as accepted by candidates of various levels of experience. Although this study highlights potential future use of such technology, the current version of the Google GLASS may not be the ideal device for application due to its cost and battery issues. Nevertheless, as technology evolves, we can be sure to anticipate the use of such devices within the medical field to improve patient care.

ACKNOWLEDGEMENTS

MHI is most thankful to the Malcolm Coptcoat Memorial Trust for the BSc Studentship Grant, enabling the authors to conduct this study. AA, KA and PDG acknowledge support from The Urology Foundation. PDG and KA also acknowledge support from the NIHR Biomedical Research Centre, MRC Centre for Transplantation, King's Health Partners, Guy's and St. Thomas' Charity, School of Surgery, London Deanery, Olympus, Royal College of Surgeons of England, Intuitive Surgical, EU-FP7, Prostate Cancer UK, Technology Strategy Board and The Vattikuti Foundation.

REFERENCES

[1] Shao P, Ding H, Wang J, et al. Designing a wearable navigation system for image-guided cancer resection surgery. Annals of biomedical engineering. 2014 Nov: **42**:2228-37

[2] Chimenti PC, Mitten DJ. Google Glass as an Alternative to Standard Fluoroscopic Visualization for Percutaneous Fixation of Hand Fractures: A Pilot Study. Plastic and reconstructive surgery. 2015 Aug: **136**:328-30

[3] Schaer R, Salamin F, Alfonso O, et al. Live ECG readings using Google Glass in emergency situations. Conf Proc IEEE Eng Med Biol Soc. 2015 Aug: **2015**:315-8

[4] Stetler J, Resendes E, Martinez-Parachini JR, et al. Hands-free zoom and pan technology improves the accuracy of remote electrocardiogram interpretation using Google Glass. International journal of cardiology. 2016 Feb 1: **204**:147-8

[5] Dickey RM, Srikishen N, Lipshultz LI, Spiess PE, Carrion RE, Hakky TS. Augmented reality assisted surgery: a urologic training tool. Asian journal of andrology. 2015 Nov 27:

[6] Knight HM, Gajendragadkar PR, Bokhari A. Wearable technology: using Google Glass as a teaching tool. BMJ case reports. 2015: **2015**

[7] Aydin A, Muir G, Graziano M, Khan M, Dasgupta P, Ahmed K. Validation of the GreenLightTM Simulator and development of a training curriculum for photoselective vaporisation of the prostate. BJU Int Journal Translated Name BJU International. 2015 01 Jun: **115**:994-1003

[8] Brewin J, Tang J, Dasgupta P, et al. Full immersion simulation: validation of a distributed simulation environment for technical and non-technical skills training in Urology. BJU international. 2014 Jul 23:

[9] Brunckhorst O, Shahid S, Aydin A, et al. Simulation-based ureteroscopy skills training curriculum with integration of technical and non-technical skills: a randomised controlled trial. Surg Endosc. 2015 Sep: **29**:2728-35

[10] Cancela J, Pastorino M, Tzallas AT, et al. Wearability assessment of a wearable system for Parkinson's disease remote monitoring based on a body area network of sensors. Sensors (Basel). 2014: **14**:17235-55

[11] Hassan M, Kadone H, Suzuki K, Sankai Y. Wearable gait measurement system with an instrumented cane for exoskeleton control. Sensors (Basel). 2013: **14**:1705-22

[12] Hicks SL, Wilson I, Muhammed L, Worsfold J, Downes SM, Kennard C. A depth-based head-mounted visual display to aid navigation in partially sighted individuals. PloS one. 2013: **8**:e67695

[13] Iqbal MH, Aydin A, Brunckhorst O, Dasgupta P, Ahmed K. A review of wearable technology in medicine. J R Soc Med. 2016 Oct: **109**:372-80

[14] NICE. Recognising and responding appropriately to early signs of deterioration in hospitalised patients. 2007 [cited 17 April 2015]; Available from:

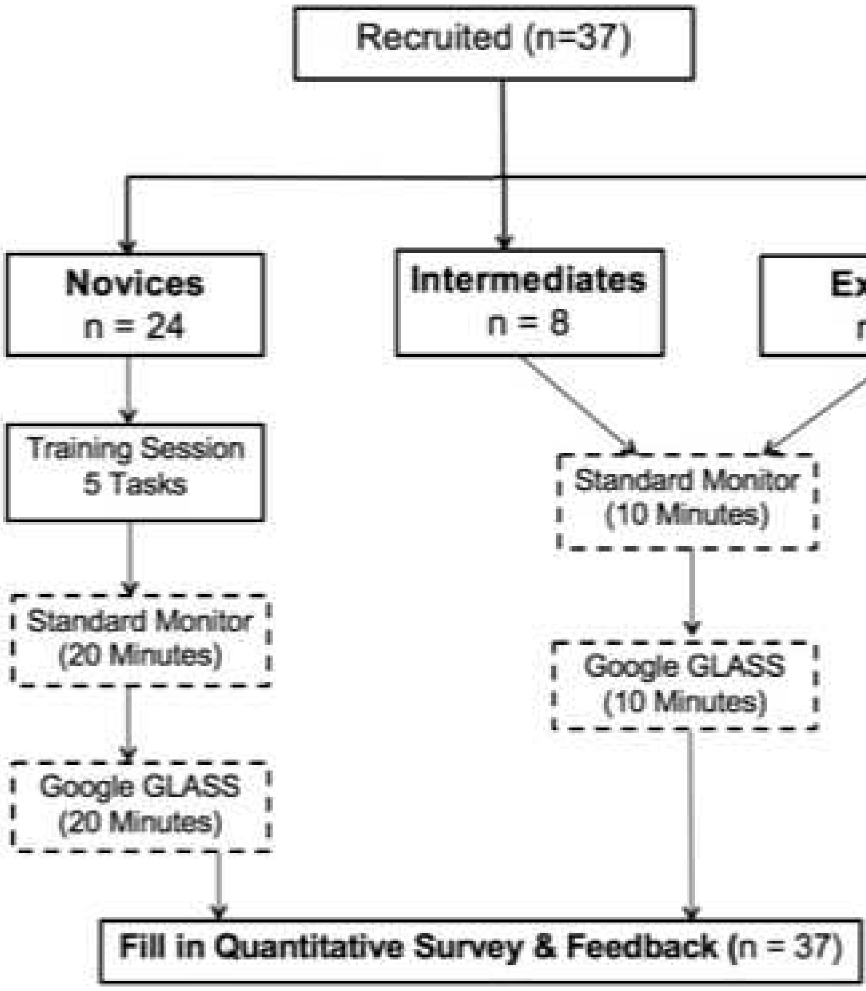
[15] Wheatley I. The nursing practice of taking level 1 patient observations. Intensive and Critical Care Nursing. 2005: **22**:115-21

FIGURE LEGENDS

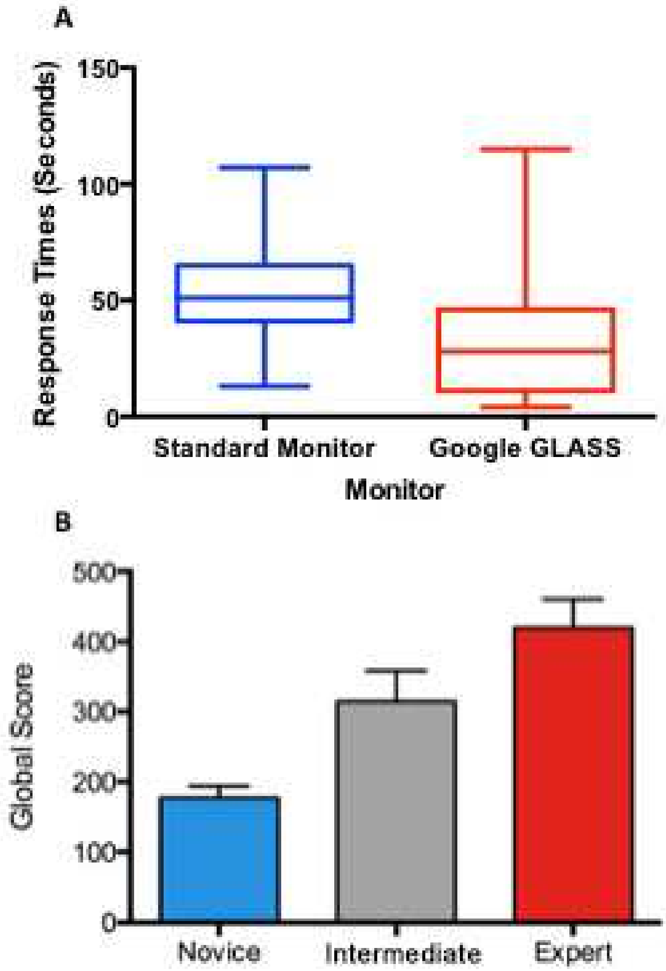
Figure 1: Study process

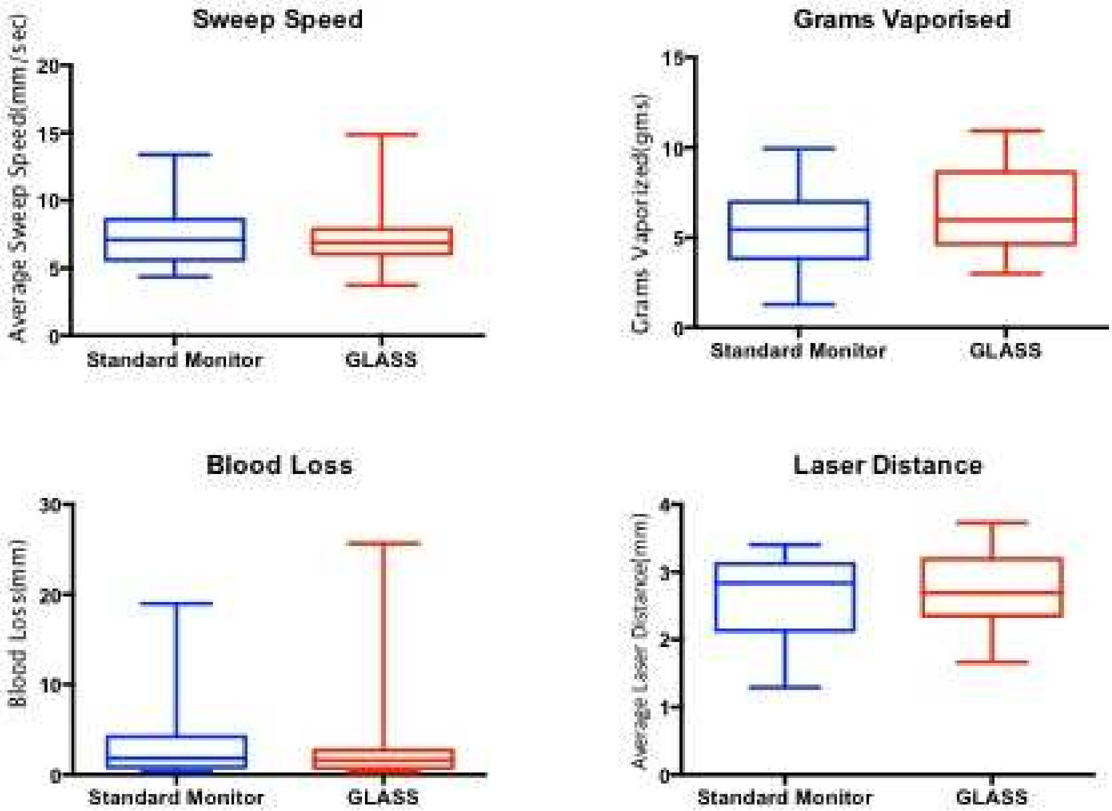
Figure 2: (A) Vital signs response times (P=0.0267) and (B) Difference between novices vs intermediates (p=0.0038), novices vs experts (p<0.0001) and intermediates vs experts (p=0.13).

Figure 3: Parameters from Simulation sessions: Sweep Speed (p=0.594), Blood Loss (p=0.761), Grams Vaporised (p=0.102) and Laser Distance (p=0.547)



Recruited (n=37)
Novices
n = 24
Intermediates
n = 8
Experts
n = 5
Training Session
5 Tasks
Standard Monitor
(20 Minutes)
Google GLASS
(20 Minutes)
Standard Monitor
(10 Minutes)
Google GLASS
(10 Minutes)
Fill in Quantitative Survey & Feedback (n = 37)


A
Response Times (Seconds)
150
100
50
0
Standard Monitor
Google GLASS
Monitor
B
Global Score
500
400
300
200
100
0
Novice
Intermediate
Expert


Sweep Speed
Average Sweep Speed(mm/sec)
0
5
10
15
20
Standard Monitor
GLASS
Grams Vaporised
Grams Vaporized(gms)
0
5
10
15
Standard Monitor
GLASS
Blood Loss
Blood Loss(mm)
0
10
20
30
Standard Monitor
GLASS
Laser Distance
Average Laser Distance(mm)
0
1
2
3
4
Standard Monitor
GLASS

HIGHLIGHTS

- The use of head-mounted displays (HMDs) have previously been demonstrated within the medical field

- The majority (84%) of participants responded quicker to abnormal signs with the Google GLASS compared to a standard monitor

- Surgical performance between both sessions was similar and not hampered by the use of Google GLASS.

International Journal of Surgery Author Disclosure Form

The following additional information is required for submission. Please note that failure to respond to these questions/statements will mean your submission will be returned. If you have nothing to declare in any of these categories then this should be stated.

Please state any conflicts of interest

None

Please state any sources of funding for your research

The authors acknowledge and thank the Malcolm Coptcoat Trust for providing the financial support to conduct this study, in the form of Student BSc Grant to MHI. PDG and KA acknowledge support from the NIHR Biomedical Research Centre, MRC Centre for Transplantation, King's Health Partners, Guy's and St. Thomas' Charity, School of Surgery, London Deanery, Royal College of Surgeons of England, Intuitive Surgical, The Urology Foundation, Olympus, EU-FP7, Prostate Cancer UK, Technology Strategy Board and The Vattikuti Foundation.

Please state whether Ethical Approval was given, by whom and the relevant Judgement's reference number

N/A

Research Registration Unique Identifying Number (UIN)

Please enter the name of the registry and the unique identifying number of the study. You can register your research at http://www.researchregistry.com to obtain your UIN if you have not already registered your study. This is mandatory for human studies only.

None

Author contribution

Please specify the contribution of each author to the paper, e.g. study design, data collections, data analysis, writing. Others, who have contributed in other ways should be listed as contributors.

MHI, AA and KA devised the study methodology. MHI, AA, AL and HIA conducted the study. PDG, MSK, GHM and KA provided critical feedback and supervision during the length of the study.

Guarantor

The Guarantor is the one or more people who accept full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

Abdullatif Aydin, Kamran Ahmed, Prokar Dasgupta