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REMOTE CONSULTING IN BONE-ANCHORED HEARING IMPLANT SURGERY USING SMART GLASSES

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Background

Among the recent technological innovations in medicine, the use of smart glasses in remote surgeries has emerged as a promising tool. These devices enable access to real-time information, visualization of diagnostic images, and remote expert guidance during surgical procedures.

Objectives

2.1 Primary:

-To evaluate the applicability of smart glasses for remote surgical consulting in auditory prosthesis implantation procedures.

2.2 Secondary:

- To assess the quality of audio and video during real-time surgical transmission.
- To evaluate the acceptance of the remote consulting model using smart glasses by both local surgeons and remote consultants.
- To identify technical challenges and limitations of the use of smart glasses for remote consulting.

Method

A prospective observational study was conducted to evaluate the functionality of smart glasses in auditory prosthesis implant surgeries. The study involved surgeons who performed the procedures using smart glasses model Vuzix M400 (Vuzix corporation, USA) integrated in the system Rods & Cones® (Rods & Cones, Belgium) and remote consultants who assisted and provided guidance also via Rods & Cones®. Prior to participation, all individuals underwent informed consent procedures.

Surgeries were performed in multiple centers across Latin America. The coordinating center was the Hospital de Reabilitação de Anomalias Craniofaciais - University of São Paulo (HRAC-USP).

The study was conducted in three phases:

Phase 1 – Training and adaptation: Participants were trained in the use of smart glasses.

Phase 2 – Surgical procedures: Surgeries were performed with real-time remote support.

Phase 3 – Feedback collection: Data were gathered through online questionnaires and analysis of technical incidents, challenges, and limitations experienced during the procedures.

Results

A total of 17 bone-anchored hearing implant surgeries were performed, involving 34 participants, but the study is still ongoing. The procedures included 16 OSIA® (Cochlear Ltd., Australia) and one BAHA® Connect (Cochlear Ltd., Australia).

Among local surgeons the mean surgical time reported was 1h 15min ± 24min. Four participants reported times shorter than one hour, the shortest being 30 minutes—the only BAHA Connect surgery. Perception

regarding the comfort of using smart glasses was rated 9.06 ± 1.39 on a scale from 0 to 10 (0–10), one individual gave a score of four, citing variation in battery position during the procedure as a reason. Open-ended feedback was also given: for improvement, beyond the ergonomic issue related to the battery, initial difficulty with internet connection was also mentioned. Overall satisfaction among local surgeons was 9.41 ± 1.39 (0–10), with all ratings above eight, except for two participants who rated it as five. These two also reported local internet instability and difficulties setting up the equipment in the operating room. As a positive aspect, surgeons highlighted the possibility of receiving support during complex cases.

Among remote consultants, mean surgical time reported was 1h 20min ± 28min, similar to their local counterparts; audio quality was rated 8.29 ± 1.10 (0–10); video quality 8.47 ± 0.62 (0–10). Most remote surgeons reported intervening only when requested, with no need for frequent direct action. Overall satisfaction 8.76 ± 1.56 (0–10), with two ratings of five, which coincided with the two lowest ratings from on-site surgeons. As limitations, 47.05% (n=8) participants highlighted the reliance on a stable internet connection. Positive aspects included the ability to assist a colleague remotely in more complex cases, the audiovisual quality, and the ease of use.

As for complications, there was only one case of excessive bleeding during an OSIA surgery, mentioned by both the local and remote surgeons. Despite this report, there was no change in surgical time compared to the others.

Both the on-site and remote surgeons stated they would use smart glasses in surgeries again.

Discussion

Smart glasses show great potential for surgical education and remote collaboration, especially in low- and middle-income countries. These devices enable real-time video transmission and direct interaction, facilitating surgical training and professional support across different geographic regions.

The integration of smart glasses into surgical practice is a continuously evolving area, with several promising applications and ongoing discussions regarding their potential benefits and limitations. These technologies are being assessed for their ability to enhance surgical accuracy, improve situational awareness, and support remote education and collaboration (Tu et al., 2024).

Ideally, the best way to evaluate the effectiveness of smart glasses in surgery would be through the impact on patient clinical outcomes. However, no system is currently at the stage of a large-scale clinical trial for this purpose (Birlo et al., 2022). Most studies, including this one, remain focused on identifying and proposing solutions to usability challenges.

One of the main challenges is optical resolution and image quality, which may be inadequate for applications like telementoring, where visual clarity is critical for safety and effectiveness (Sommer et al., 2022). The Vuzix M400 smart glasses used in this project has a resolution of 4K at 30 fps or 1080p at 60 fps, as described by the manufacturer (VUZIX, 2025), surpassing other smart glasses currently used in surgery. This technical advantage may explain the high acceptability ratings for visual quality shown in our preliminary results.

Another challenge often reported in the literature—but not observed in our sample—is insufficient battery life for the duration of the surgery (Baashar et al., 2023). There were no complaints regarding battery duration or cable ergonomics; however, one complaint was raised about the unstable positioning of the device's battery, a point not yet described in the literature.

Finally, the lowest satisfaction ratings in our study coincided with cases where audio failure was related to unstable internet connections. Connectivity issues are widely reported as a barrier to the effectiveness of

smart glasses, especially in low- and middle-income countries (Rojas-Muñoz et al., 2019; Smit et al., 2024).

Conclusion

Audio and video quality were positively evaluated by remote consultants. The remote consulting model using smart glasses showed high acceptance among both user groups, with 100% of participants reporting willingness to use the technology again.The main technical challenges were related to internet connectivity issues.

Despite these challenges, overall, the preliminary findings reinforce the potential of smart glasses as an innovative tool for remote support in otologic surgeries, with high acceptance among specialists and practical applicability in real-time training and supervision.

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