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Apple Vision Pro as a wearable display for endoscopic dacryocystorhinostomy: Surgical experience, efficiency, and cost

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ABSTRACT

Objective: To evaluate the Apple Vision Pro (AVP), a wearable spatial computing headset, as the primary intraoperative display for endoscopic dacryocystorhinostomy (DCR), assessing operative efficiency, ergonomics, cognitive workload, and cost.

Design: Consecutive, non-randomized comparative study at a single academic center, following institutional review board approval.

Subjects and controls: Thirty-two consecutive endoscopic DCR procedures were analyzed: 16 with the AVP and 16 size-matched controls. Two fellows were the primary surgeons; three attending surgeons assisted.

Methods: Endoscopic DCR for primary unilateral nasolacrimal duct obstruction was performed using either the AVP or a traditional tower-mounted monitor for intraoperative visualization. Outcomes were operative time, functional success, intraoperative complications, surgeon-reported ergonomics, and perceived workload measured with the NASA Task Load Index (NASA-TLX). An exploratory cost analysis was also performed.

Results: Groups were comparable in age and sex. Operative time was shorter with the AVP (34.4 ± 8.6 vs 42.7 ± 8.5 min; reduction approximately 8.3 min, about 19%; $p = 0.006$). Functional success was 100% in both groups (16 of 16) with no complications; follow-up was 4 to 12 months. Overall workload was lower with the AVP (median 19.2 vs 40.0; one-sided $p = 0.031$; mean reduction 14.3 points, 95% CI 2.4 to 26.2; dz = 1.50); all five surgeons favored the AVP, with the largest reduction in physical demand, and subscale differences did not survive multiplicity correction. Surgeons reported improved comfort and a more neutral head and neck posture. The AVP occupied a small fraction of the cost and footprint of standard operating-room equipment.

Conclusions: In this preliminary, non-randomized series, use of the AVP as a wearable display for endoscopic DCR was associated with shorter operative times and lower surgeon-reported workload while occupying minimal space. As among the first prospective evaluations of the device for endoscopic lacrimal surgery, these findings suggest ergonomic and workflow advantages but require confirmation in larger, controlled studies.

Introduction

Spatial computing refers to a mode of computing in which digital content is no longer confined to a flat, two-dimensional screen but is instead placed within, and interacted with, in the user's three-dimensional physical environment. Apple Inc, which brought the term into mainstream use, describes spatial computing as an approach that blends digital content with the physical world, creating a visual canvas that extends beyond the boundaries of a conventional display and is navigated through natural inputs such as the eyes, hands, and voice. In

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practical terms, spatial computing allows high-resolution visual information to be positioned freely in space and viewed hands-free, according to the user's line of sight, rather than on a fixed external monitor.

Since its introduction, spatial computing has begun to reshape workflows across many industries. Head-worn systems are used to guide maintenance, assembly, and training in aviation and manufacturing, to review full-scale three-dimensional models in engineering and design, and to support remote assistance and logistics, in each case freeing complex visual information from a fixed screen and presenting it, hands-free, within the user's field of view.

In medicine, spatial computing and wearable head-mounted displays have been applied across a growing range of clinical and surgical settings, including preoperative planning and surgical navigation,[1,2] and intraoperative visualization in urologic,[3] dermatologic,[4] orthopedic,[5] and ophthalmic[6,7] procedures. Most relevant to the operating room, head-anchored displays have recently been used to give surgeons a direct, hands-free view of the operative field, including the first reported use of an augmented-reality headset in minimally invasive general surgery.[8] By decoupling the surgeon's line of sight from a fixed external monitor, such displays may also improve intraoperative ergonomics, an important consideration given the high prevalence of neck and back strain among surgeons who work in sustained, non-ergonomic postures.[9–11]

Endoscopic dacryocystorhinostomy (endoDCR) has become a mainstay in the surgical management of nasolacrimal duct obstruction and is now common practice among lacrimal surgeons. Compared with the traditional external approach, the endonasal route avoids a cutaneous incision and provides direct visualization of the intranasal surgical field while achieving comparable success rates.[12,13] Because the procedure is performed entirely under nasal endoscopy, with the operative image displayed on an external monitor, it is a natural setting in which to evaluate a wearable, head-anchored display.

A leading example of this technology is the Apple Vision Pro (AVP, Cupertino, CA), a spatial computing headset released in February 2024. The AVP combines an ultra-high-resolution display, control through the eyes, hands, and voice, and an open software development environment, making it well suited for integration into clinical workflows.

In the present study, we evaluated endoscopic DCR performed with the AVP as a wearable, high-resolution display and compared it with traditional monitor-based endoscopy, assessing surgical outcomes, surgeon workload, and economic feasibility. To our knowledge, this is among the first prospective evaluations of the Apple Vision Pro used as the primary intraoperative display for endoscopic lacrimal surgery.

Methods

Study design and participants

A consecutive, non-randomized study of endoscopic dacryocystorhinostomy (endoDCR) visualized with a traditional, endoscopic tower-mounted monitor versus the Apple Vision Pro (AVP) was conducted at a single academic center (University of California, San Diego). The AVP was introduced as an intraoperative display during the study period; cases were performed with the AVP when a headset was available and with the traditional monitor when it was not. The study adhered to the Declaration of Helsinki, received institutional review board approval, and complied with HIPAA regulations.

Eligible patients were adults (18 years or older) with unilateral primary acquired nasolacrimal duct obstruction, symptomatic epiphora, and obstruction confirmed on lacrimal irrigation. Patients were excluded for canalicular or congenital obstruction, prior dacryocystorhinostomy, nasal septal deviation precluding endoscopic access, concomitant procedures, facial nerve palsy, or inflammatory or systemic disease affecting the lacrimal system (for example, sarcoidosis or granulomatosis with polyangiitis). All cases were primary, unilateral endoDCR, with no revisions.

Two fellows served as the primary surgeons and three attending surgeons assisted, holding the endoscope. To limit confounding by surgeon, each fellow contributed a comparable number of cases to both arms (traditional group: Fellow 1, 9 cases and Fellow 2, 7 cases; AVP group: 8 cases each), and the two groups were of equal size (16 per group).

The primary efficiency outcome was total operative time, extracted from the electronic health record; the primary workload outcome was the overall raw NASA Task Load Index (NASA-TLX) score, with the six domains as secondary outcomes. Functional success was defined as symptomatic relief with a patent lacrimal system on irrigation at the most recent follow-up. No a priori power calculation was performed; the sample comprised consecutive eligible cases, so the study is best regarded as preliminary and hypothesis-generating rather than a definitive test of superiority.

NASA-TLX assessment

Each of the five surgeons completed the NASA-TLX once for their aggregate experience operating with the AVP and once with the traditional monitor, so that each served as their own control rather than rating individual cases. The NASA-TLX is a validated instrument that quantifies perceived workload across six subscales (mental demand, physical demand, temporal demand, performance, effort, and frustration), each rated from 0 to 100 and averaged into an overall raw score, with higher values indicating greater workload.[14]

Overall raw NASA-TLX was the pre-specified primary endpoint; the six subscales were secondary and exploratory. Because each surgeon rated both conditions, scores were paired and compared with the Wilcoxon signed-rank test, reported as median and interquartile range with paired effect sizes (dz); one-sided tests reflected the a priori directional hypothesis, and the subscales were interpreted with Holm correction for multiplicity. Operative time and baseline age were summarized as mean $\pm$ standard deviation and compared with the Mann-Whitney U test, with the independent-samples *t*-test reported for concordance. Exact p-values are reported. Analyses used SPSS (version 30.0.0.0; IBM, Chicago, Illinois).

Wireless transmission configuration for AVP visualization

For AVP cases, the HDMI output of the endoscopy tower was converted to Network Device Interface (NDI) format and streamed over a secured, closed 5 GHz Wi-Fi 6 network dedicated to low-latency intraoperative video and isolated from institutional systems to protect patient information and maintain throughput. The stream was delivered in real time to each headset worn by the operating surgeon and assistant. Performance was stable throughout, with no latency perceptible to the surgeons; latency was not objectively quantified.

Results

A total of 32 consecutive endoscopic dacryocystorhinostomy (endoDCR) procedures were analyzed in this prospective, non-randomized study, with 16 procedures performed using the Apple Vision Pro and 16 performed using standard monitor-based endoscopy. All analyzed cases were unilateral primary endoDCR; bilateral cases were excluded to keep operative time comparable, and the two primary surgeons each contributed a comparable number of cases to both groups. Mean patient age was 67.3 ± 13.7 years in the Apple Vision Pro group and 59.6 ± 17.0 years in the traditional group ($p = 0.17$). The age and sex did not differ significantly between groups.

In the traditional group, surgeons utilized a Stryker (Kalamazoo, MI) endoscopy platform composed of an image processing unit, fiber optic light source, and camera module connected to a 32-inch 4 K monitor mounted on a mobile cart. The cart occupied approximately 5 square feet of floor space. During surgery, the primary surgeon and assistant were positioned on opposite sides of the patient's head, with the shared monitor placed at the head of the bed. To view the monitor, both surgeons had to rotate their upper bodies approximately 90 degrees away from their forward-facing posture (Fig. 1).

In the AVP group, the Apple Vision Pro headset was used as the primary and sole visualization platform. Both the operating surgeon and assistant wore separate AVP devices that displayed the live endoscopic video feed directly within their individual visual fields (Fig. 2). This configuration allowed both users to maintain a natural forward-facing posture throughout the procedure, eliminating the need for monitor sharing or body rotation. AVP provided an immersive, spatially anchored image that could be adjusted dynamically in space and dimension according to the surgeon's preference. Video 1 demonstrates real-time use of the Apple Vision Pro during surgery, showing how surgeons use sterile hand gestures to reposition, resize, or adjust the virtual display without disrupting the operative field. The high-resolution endoscopic feed was wirelessly streamed into each headset in real time using a single NDI broadcast stream.

Although the AVP headset served as the sole visualization tool during the procedures, the traditional 32-inch monitor remained powered on in the room as a redundant backup in case of headset failure. However, in AVP cases, the monitor was repositioned to the foot of the bed, rather than the head, to reduce crowding and potential distraction. There were no cases were the AVP use was aborted and the external screen was not utilized for any portion of the surgery in any of the AVP cases, but its presence provided a safety net should technical failure have occurred in the headset.

Total operative time was extracted from the electronic health record (Epic Systems Corporation, Verona, WI) for each procedure. Operative time was shorter in the Apple Vision Pro group (mean 34.4 ± 8.6 min) than in the traditional group (mean 42.7 ± 8.5 min; Mann-Whitney U test, $p = 0.006$; independent-samples t-test concordant, $p = 0.010$). This corresponds to a reduction in mean operative time of approximately 8.3 min per case, or about 19%. Functional success was achieved in 16 of 16 Apple Vision Pro cases and 16 of 16 traditional cases, and follow-up ranged from 4 to 12 months (median 7 months), with no intra-operative complications in either group. Because operative time can be influenced by factors other than the visualization system, the two primary surgeons each contributed a comparable number of cases to both groups, and operative times were reviewed sequentially across the Apple

Fig. 1. Conventional setup for endoscopic dacryocystorhinostomy. The endoscopic tower with a single monitor is positioned at the head of the bed, requiring all surgical team members to crowd around a single visual display. This configuration may contribute to ergonomic strain and limits individualized viewing angles for trainees and assistants, highlighting the potential need for more flexible visualization technologies.

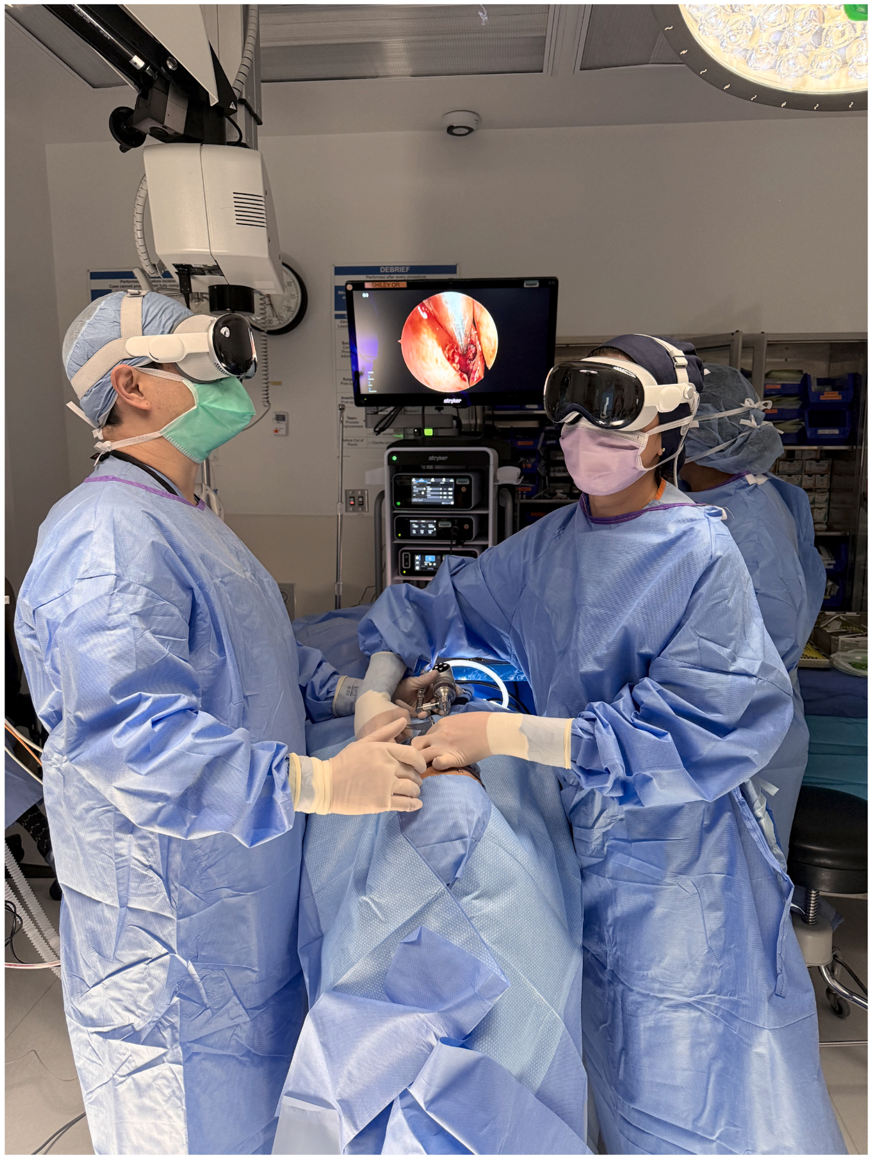

Fig. 2. Apple Vision Pro setup for endoscopic dacryocystorhinostomy. Both the surgeon and assistant wear AVP through the surgery while the monitor at the foot of the bed remains for backup redundancy. Optimal surgeon ergonomics are maintained through the entire surgery.

Vision Pro cases, which did not show a progressive decline that would indicate a device or procedure learning curve.

Ergonomic comfort was subjectively assessed through direct post-procedural feedback. Surgeons in the AVP group reported improved neck and shoulder comfort due to the ability to maintain a neutral head position. No issues with motion sickness, headset weight, or headset fogging were reported during the study period. Each of the five surgeons also completed the NASA Task Load Index (NASA-TLX) for their aggregate experience with each visualization condition to assess perceived cognitive workload.

Table 1
Perceived intraoperative workload with the Apple Vision Pro versus the traditional monitor.

NASA-TLX domain	Apple Vision Pro Median (IQR)	Traditional monitor Median (IQR)	Surgeons favoring AVP	Effect size (dz)	p value	Holm-adjusted p
Overall (raw NASA-TLX)	19.2 (15.8–30.0)	40.0 (30.8–41.7)	5/5	1.50	**0.031**	Primary endpoint[a]
Individual subscales (secondary)						
Mental demand	20.0 (15.0–30.0)	40.0 (20.0–50.0)	3/5	0.82	0.125	0.375
Physical demand	15.0 (15.0–30.0)	60.0 (50.0–60.0)	5/5	1.63	0.031	0.188
Temporal demand	20.0 (15.0–30.0)	25.0 (20.0–50.0)	2/5	0.69	0.250	0.500
Performance	15.0 (5.0–25.0)	15.0 (10.0–15.0)	2/5	0.18	0.375	0.500
Effort	25.0 (20.0–35.0)	50.0 (40.0–50.0)	4/5	1.29	0.062	0.312
Frustration	20.0 (10.0–20.0)	45.0 (20.0–50.0)	4/5	0.97	0.062	0.312

Values are the median (interquartile range) of the aggregate rating provided by each of the five surgeons for each visualization condition; higher scores indicate greater workload.
Abbreviations: AVP, Apple Vision Pro; IQR, interquartile range; NASA-TLX, National Aeronautics and Space Administration Task Load Index.

Perceived workload was lower with the Apple Vision Pro across all six NASA-TLX subscales and for the overall score (Table 1). For the pre-specified primary endpoint, overall workload was significantly lower with the Apple Vision Pro (median 19.2, IQR 15.8 to 30.0) than with the traditional monitor (median 40.0, IQR 30.8 to 41.7), with all five surgeons reporting lower workload with the Apple Vision Pro (Wilcoxon signed-rank test, one-sided $p = 0.031$; mean reduction 14.3 points, 95% confidence interval 2.4 to 26.2; paired effect size dz = 1.50). Among the exploratory subscales, the reduction was largest and most consistent for physical demand (all five surgeons lower; one-sided $p = 0.031$; dz = 1.63), with effort and frustration showing large but non-significant reductions after accounting for multiple comparisons. Given the small number of raters and the exploratory nature of the subscale analyses, these domain-level differences are reported as hypothesis-generating rather than confirmatory. Taken together, the findings indicate that the Apple Vision Pro did not increase, and likely reduced, perceived intraoperative workload, consistent with surgeons' subjective reports of improved comfort.

In terms of equipment footprint, the AVP system required minimal physical space. When stored, each headset occupied approximately 0.04 square meters. It is important to note that the endoscopy tower, including its camera module, light source, and image processor, remains essential for AVP-assisted cases; only the monitor is replaced. The primary spatial benefit of AVP is therefore not elimination of the tower but rather its repositioning. In AVP cases, the tower was moved to the foot of the bed, away from the surgical field, reducing crowding at the head of the bed and improving staff mobility and room configuration. This repositioning, combined with the elimination of monitor cables at the surgical field, has meaningful implications for room layout and workflow efficiency (Fig. 3).

Finally, a relative cost analysis was performed based on institutional capital equipment estimates. The AVP system represented approximately 0.5 percent to 0.7 percent of the total capital cost of a standard endoscopic operating room. This positions it within the cost category of ancillary tools such as patient warmers or stools, rather than major imaging platforms. Fig. 4 illustrates this comparison on a logarithmic cost scale, with the AVP highlighted to demonstrate its relatively low financial footprint in the context of other operating room equipment.

Discussion

Spatial computing, exemplified by devices such as the Apple Vision

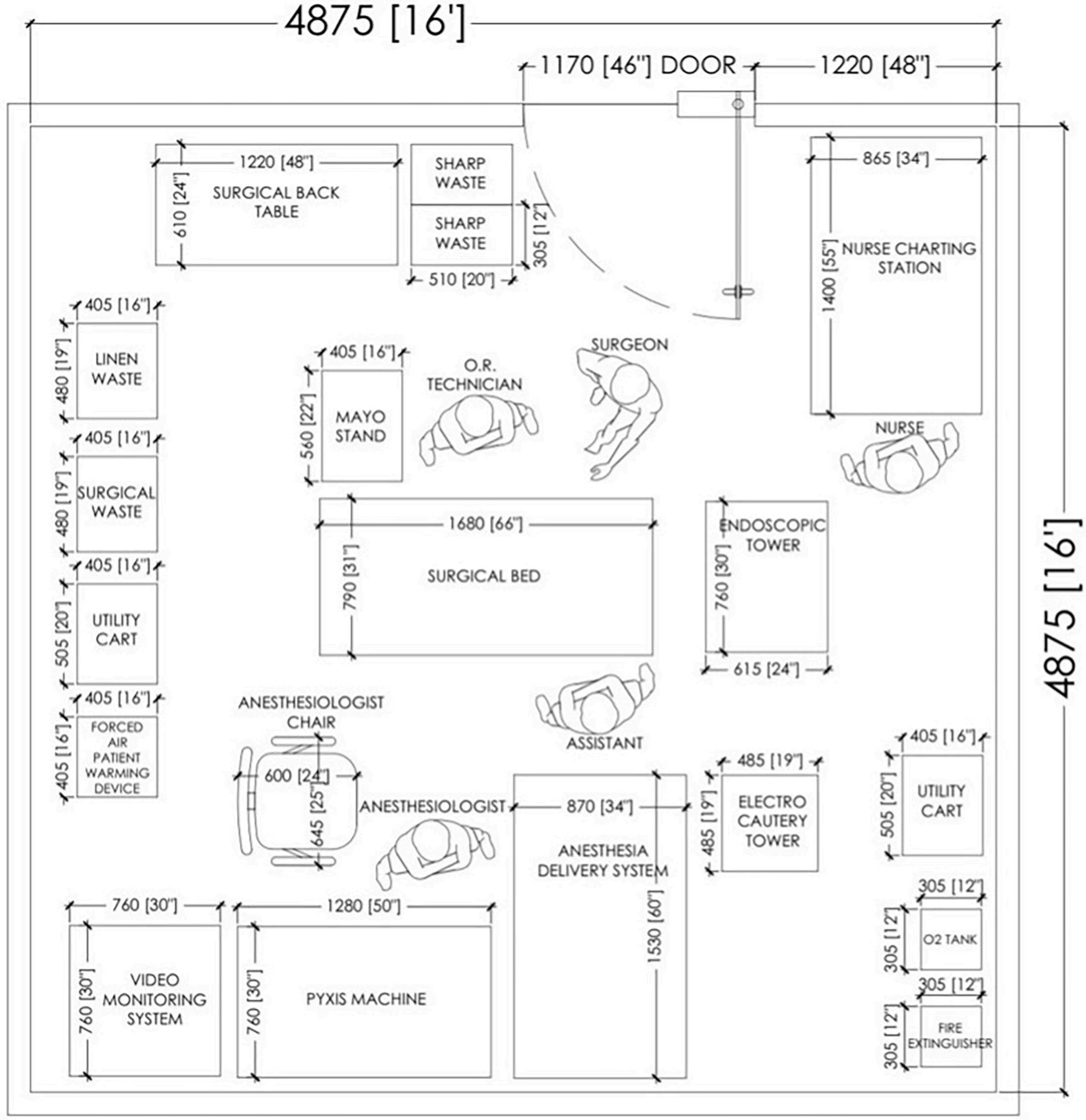

Fig. 3. Operating room floor plan demonstrating the space constraints of a typical endoscopic surgical suite, including positioning of the endoscopy tower, surgical bed, anesthesia equipment, and support staff.

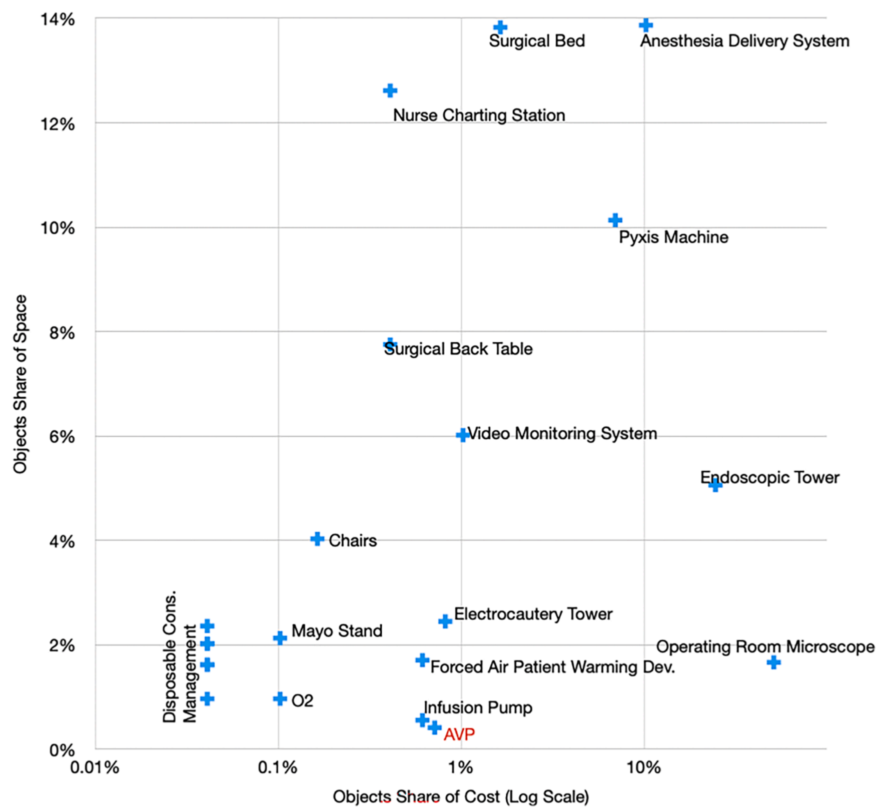

Fig. 4. Comparison of operating room equipment by cost (logarithmic scale) and space utilization.

Pro (AVP), is rapidly emerging as a transformative technology in surgery. By integrating high-resolution imaging with immersive head-mounted displays, these systems have the potential to enhance both technical performance and surgeon well-being.

Several recent studies have explored AVP in surgical settings with varying approaches.

Orione et al. reported the first use of AVP in oculoplastic surgery, utilizing the device's pass-through camera mode to visualize the surgical field.[7] Broderick et al. demonstrated direct integration of laparoscopic video feeds into the AVP display for minimally invasive general surgery, reporting NASA-TLX workload scores of 22.3 ± 4.7 across 41 cases.[8] Our approach follows this direct video feed model. While Nowak et al. previously described the use of virtual reality and mixed reality for intraoperative guidance in extremely complex congenital and post-traumatic lacrimal obstructions, and Zloto et al. reported virtual reality for preoperative DCR planning, the present study differs in three important respects: it uses the Apple Vision Pro specifically, it employs spatial computing as the sole intraoperative visualization platform replacing the monitor entirely, and it evaluates its use in a prospective consecutive series of routine endoscopic DCR cases rather than selected complex cases.[15,16] Unlike pass-through visualization, direct endoscope streaming provides full resolution of the endoscopic image and enables independent positioning of the virtual display within each surgeon's field of view. This distinction carries practical implications: while pass-through mode maintains ambient awareness, direct streaming offers superior image fidelity, which is particularly important given the confined anatomy of the nasal cavity and lacrimal system. Unlike augmented reality systems that overlay additional data or surgical guidance into the operative field, the AVP in this study functioned solely as a high-resolution display, directly replacing the conventional monitor. The reduction in operative time is therefore attributable not to augmented information processing but to the elimination of head rotation and the individualized visual field that allowed each surgeon to maintain a natural, forward-facing posture throughout the procedure, consistent with ergonomic improvements reported in minimally invasive general surgery.[8]

Traditional endoscopic setups require surgeons to rotate their heads and necks to view monitors positioned off-axis. This posture, maintained for extended periods, can lead to musculoskeletal strain, chronic fatigue, and long-term cervical spine injury. Such ergonomic challenges contribute to surgeon burnout and may affect both patient care quality and career longevity.

The AVP addresses these concerns by allowing surgeons to maintain a neutral, forward-facing posture with a virtual monitor positioned directly in their line of sight. This configuration minimizes head rotation, reducing the risk of cervical injury and alleviating physical fatigue. The device also provides a consistent 4K-quality image free from glare and viewing angle limitations common with traditional monitors, facilitating more precise surgical maneuvers and detailed anatomical assessment.

The NASA-TLX results in this study support these subjective reports. While reductions were observed across all workload domains, the statistically significant decreases in physical demand, effort, and overall workload align with surgeons' feedback describing reduced neck and shoulder strain. These findings are consistent with prior NASA-TLX research in other specialties, where ergonomic improvements were associated with lower physical demand scores.[17] The convergence of quantitative workload data and qualitative comfort reports suggests that AVP offers measurable ergonomic benefits beyond the practical advantages of individualized visualization.

Endoscopic DCR presents particular challenges that may explain the observed benefit of AVP: the need to simultaneously monitor the endoscopic view and the surgical field, limited working space within the nasal cavity requiring precise spatial orientation, and coordination between endonasal and external approaches. By consolidating the endoscopic feed directly into the surgeon's line of sight, AVP reduces the cognitive burden of dividing attention between the patient and external monitors, which may contribute to the observed reduction in operative time.

The ergonomic and visualization improvements provided by spatial computing also have implications for efficiency. In our study, Apple Vision Pro cases averaged approximately 34 min, which may reduce patient exposure to anesthesia and support operating room throughput, although these downstream effects were not directly measured. By reducing physical strain and cognitive load, this technology may help mitigate long-term occupational health issues including surgeon fatigue, cervical spine injuries, and burnout.

Beyond the direct display application evaluated here, spatial computing platforms have been described as tools for preoperative planning and intraoperative reference, for example by presenting imaging alongside the operative view. These applications were not used or evaluated in the present study, in which the Apple Vision Pro functioned solely as a wearable display, and they are noted only as potential directions rather than findings of this work.

One application directly relevant to the present setup is education. Because the headset receives the same high-resolution endoscopic feed viewed by the operating surgeon, that feed can be transmitted to remote observers in real time, allowing trainees or colleagues at other sites to see exactly what the surgeon sees during endoscopic DCR and other endoscopic procedures. We did not formally evaluate educational outcomes, and broader claims regarding resident training and skill acquisition would require dedicated study.[1,3–5]

The endoscopic approach in oculofacial surgery continues to gain popularity in sinus, orbital, lacrimal, and aesthetic surgery. This technique offers advantages over traditional open procedures: smaller incisions, reduced tissue trauma, faster recovery, lower infection risk, and shorter hospital stays.[12] Endoscopic DCR achieves success rates comparable to external DCR while providing improved aesthetic outcomes by avoiding skin incisions and visible scars, reducing wound infection, preventing lagophthalmos through preservation of the orbicularis oculi, and protecting the functional lacrimal pumping system.[13]

The economic implications of spatial computing extend beyond equipment comparisons. As the endoscopy tower remains in use with AVP, the direct capital cost comparison is between the AVP headset and the conventional surgical monitor it replaces. A standard 32-inch 4 K surgical monitor costs approximately $2000 to $5000, while two AVP headsets represent a comparable or modestly higher initial investment. When viewed in this context, the capital cost differential between the two visualization approaches is relatively modest, and the primary economic value lies in operational efficiency rather than capital cost reduction.

Childers and Maggard-Gibbons reported operating room costs of $37 per minute based on California hospital data, with personnel costs comprising $14 per minute.[18] Adjusting for medical care inflation using Bureau of Labor Statistics data (approximately 37% from 2014 to 2025), contemporary operating room costs approximate $51 per minute. Applying the observed 8.3 min reduction yields an estimated saving of roughly $420 per case, and for a practice performing 100 to 200 endoscopic DCR procedures annually this would correspond to an estimated $42,000 to $85,000 per year. These figures are exploratory rather than definitive: they are modeled projections based on assumptions regarding per-minute operating room cost and annual case volume, they are not derived from a formal cost-effectiveness analysis, and they do not incorporate recurring costs such as battery replacement, software updates, device repair, disinfection, or whether institutions must purchase dedicated headsets per room or can share devices across rooms. The economic estimates should therefore be interpreted with caution and confirmed in prospective cost analyses.

To illustrate the sensitivity of this exploratory estimate, a conservative scenario assuming half of the observed time saving (approximately 4.2 min per case) would correspond to roughly $210 per case, or an estimated $21,000 to $42,000 annually for the same practice volume. This range is presented only to show that the modeled economic signal is directional rather than precise, and it should not be read as a measured saving.

The minimal footprint of the AVP system also has implications for facility design. Smaller visualization equipment reduces storage requirements and allows flexible room configurations. The wireless architecture eliminates cable management expenses and reduces tripping hazards, improving both safety and workflow.

Regulatory considerations remain relevant for broader adoption. The Apple Vision Pro is marketed as a consumer device without FDA medical clearance. Medical devices in operating rooms typically require compliance with ISO for quality management and IEC electrical safety. While off-label surgical use is permitted, institutional review board approval is essential, as obtained for this study. Broader adoption may require evolving regulatory pathways and coordination with institutional compliance teams. An alternate pathway would be the use of a medical application specific to AVP which could meet FDA approval.

The use of AVP for endoscopic surgery has several potential limitations. Prolonged use may lead to eye strain, fatigue, and dry eyes from reduced blink rate, potentially affecting concentration. The weight of the device may cause neck discomfort during lengthy procedures, though this can be mitigated with periodic breaks and alternate head straps providing additional support. Battery life requires attention; availability of extra power modules reduces downtime. Although we encountered no latency issues, real-time high-resolution streaming with ultra-low latency remains crucial for precision surgery. Patient confidentiality requires secure networks and limited data access. Several study-specific limitations warrant mention. This was a non-randomized study at a single academic center, with sample size based on feasibility rather than formal power calculation. All procedures were performed by experienced surgeons; the learning curve for AVP-assisted surgery in less experienced hands was not assessed. Additionally, as with all non-blinded technology evaluations, surgeon familiarity and enthusiasm for novel devices may have introduced positive response bias in NASA-TLX scoring. These NASA-TLX findings should nonetheless be interpreted cautiously: they are based on aggregate ratings from only five surgeons, they are subjective, and the ergonomic conclusions in particular are supported primarily by self-report rather than objective measurement.

Several additional limitations warrant emphasis. Because the study was non-randomized and the Apple Vision Pro cases were performed after adoption of the technology, selection bias and learning-curve effects cannot be fully excluded, and the study demonstrates association rather than causation. No a priori power calculation was performed; with only 16 cases per arm the study has limited power to detect differences in rare events such as intraoperative complications (none occurred in either group), and it should not be used to draw broad safety conclusions. Potential confounders of operative time, including laterality, case complexity, surgeon identity, and time of day, were not formally modeled beyond matching case numbers between surgeons and groups; residual confounding is possible. All cases were performed at a single academic center by experienced surgeons, so the time and workload findings may not generalize to community settings, trainees, other institutions, or more complex cases. The economic estimates are modeled projections rather than measured outcomes. Given these constraints, the results are best interpreted as preliminary and hypothesis-generating.

Future studies should include randomized or propensity-matched designs, larger and multi-center cohorts, objective ergonomic and latency measurement, adequately powered safety endpoints, per-case workload assessment across surgeons of varying experience, and formal cost-effectiveness analysis. Reporting followed the STROBE guidance for observational studies, and a completed STROBE checklist is provided as a supplementary file.

Conclusion

In this preliminary, non-randomized series, use of the Apple Vision

Pro as a wearable display for endoscopic dacryocystorhinostomy was associated with shorter operative times and lower surgeon-reported workload, without added cognitive burden, while occupying minimal physical space. These findings suggest that a wearable spatial computing display may offer ergonomic and workflow advantages in endoscopic surgery. Because the study was small, single-center, and non-randomized, these results should be regarded as hypothesis-generating and confirmed in larger, controlled studies before broader conclusions about efficiency, ergonomics, or cost are drawn.

Table of contents statement (Précis)

Manuscript AJOINT-26–40 — Apple Vision Pro as a Wearable Display for Endoscopic Dacryocystorhinostomy: Surgical Experience, Efficiency, and Cost

In this consecutive, non-randomized study, endoscopic dacryocystorhinostomy for primary unilateral nasolacrimal duct obstruction was performed using either the Apple Vision Pro, a wearable spatial computing display, or a traditional tower-mounted monitor. Use of the headset was associated with shorter operative times and lower surgeon-reported workload, without added cognitive burden, while occupying minimal cost and space. Functional success was universal. These preliminary findings suggest ergonomic and workflow advantages that warrant confirmation in larger, controlled studies.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used Claude AI solely to improve grammar, clarity, and readability of the manuscript. After using this tool, the authors reviewed and edited the manuscript as needed and take full responsibility for the content of the published article.

Conflict of interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ajoint.2026.100288.

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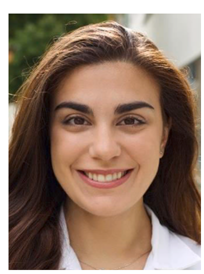

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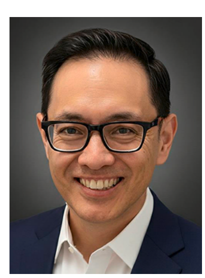

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