



# Virtual supervision in ophthalmology: a scoping review

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## Abstract

**Purpose** The published information on virtual supervision (VS) in ophthalmology is not well described. This scoping review describes the evidence and potential role for VS in ophthalmic practice and education.

**Methods** A literature search strategy was developed in accordance with Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). We included full-text articles published in an English-language peer-reviewed journal that involved physician-physician or physician-trainee VS in ophthalmology. We excluded studies with direct (in-person) supervision. Two investigators independently extracted from each article the year of publication and study location, design, participant characteristics, sample size, and outcomes. We appraised the methodological quality of the studies using the Mixed Methods Appraisal Tool (MMAT).

**Results** Seven articles were included in our qualitative synthesis. Supervisees ranged from physicians such as an ophthalmic surgeon and a general practitioner to medical trainees such as ophthalmology residents, vitreoretinal fellows, and emergency medicine residents. Study settings included emergency departments, operating rooms, eye clinics, and a rural hospital. All studies reported successful transmission of real-time images or videos of clinical examinations and surgical or in-office procedures. Various methods were used to ensure high image and video quality during VS, although some technical challenges remained. MMAT ratings revealed limitations in outcome measurement, statistical analysis, sampling strategy, and inclusion of confounding factors.

**Conclusion** Virtual supervision in ophthalmology is technologically feasible and permits synchronous communication and transmission of clinical data, which can be used to formulate diagnostic and management plans and learn new surgical skills. Future studies with larger sample sizes and robust study designs should investigate factors that make VS effective in ophthalmic practice and education.

**Keywords** Graduate medical education · Supervision · Telehealth · Medical training

## Key messages

### What is known:

- There is a paucity of research on the effectiveness of virtual supervision (VS) in ophthalmology.

### What is new:

- The literature suggests that VS in ophthalmology can be used by supervisors and supervisees to synchronously communicate and exchange data for clinical examinations, in-office procedures, and surgeries.
- High image and video quality is possible during VS, although technical challenges remain.

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## Introduction

The use of telemedicine (TM) in the USA increased dramatically in response to the COVID-19 public health emergency [1]. One application of TM is virtual supervision (VS), where the supervisor and supervisee who are not in the same physical location interact for an episode of patient care via synchronous audio and/or video modalities [2, 3]. Virtual supervision can facilitate cost-effective mentoring by specialists from remote locations and is also useful as a teaching tool in graduate medical education (GME) [4].

The information available in the literature on VS in ophthalmology is not well described. This scoping review aims to better understand the evidence and potential role for VS in ophthalmic practice and education.

## Methods

In consultation with a reference librarian, a literature search strategy was developed in accordance with Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [5]. We searched six databases (PubMed, Embase, Web of Science, CINAHL, PsycINFO, and ERIC) for articles published between January 1950 and August 2022. Our search included database-specific thesaurus terms such as medical subject headings (MeSH) and Emtree, as well as keywords related to VS in ophthalmology (Table 1).

The inclusion criteria were full-text articles published in an English-language peer-reviewed journal. We included studies that involved VS between physicians or between physicians and trainees in ophthalmology. We excluded studies in which the supervisor and supervisee were in the same physical location and studies in which clinical supervision was carried out retrospectively. We also excluded studies that included supervisors who were not ophthalmology physicians.

Eligible studies were de-duplicated in EndNote (Clarivate Analytics, Philadelphia, PA) and imported into the systematic review software Covidence (Melbourne, Victoria, Australia) for screening, full-text review, and data extraction. The screening and selection process is displayed in a PRISMA flowchart (Fig. 1). Two investigators (CK and CS) independently conducted title/abstract screening, full-text review, and data extraction in Covidence. Disagreements were resolved by the senior investigator (PBG).

A data template was developed in Covidence to extract relevant information, including year of publication, location, study design, characteristics of study participants,

sample size, and any type of outcome. Two investigators (CK and CS) independently appraised the methodological quality of the studies using the Mixed Methods Appraisal Tool (MMAT), and disagreements were resolved by the senior investigator (PBG). The Mixed Methods Appraisal Tool (MMAT) appraises studies based on five questions assessing the sampling strategy, outcome measurement, confounders, and statistical analysis of the study [6]. All studies were scored on a scale of 1 to 5 based on the MMAT.

## Results

### Study characteristics

The initial database search yielded a total of 2700 articles. Following duplicate removal, title and abstract screening, and full-text review, seven articles were included in our qualitative synthesis (Fig. 1): four were case reports or case series (57%) [7–10], two were cohort studies (29%) [11, 12], and one was a cross-sectional study (14%) (Table 2) [13]. The publication year of the articles ranged from 1998 to 2022. Most studies were conducted in the USA. Other studies were conducted in Finland [13], Israel [11], the UK [12], and the Philippines [9]. Three studies were prospective in design (43%) [8–11, 13], while other studies were retrospective (14%) [12] or both (14%) [7]. The objective of the studies ranged from determining the feasibility of a teleconference device (43%) [9, 11, 13], describing the use of VS in an emergency department (ED) or rural hospital (43%) [7, 8, 10], or determining whether fellows could safely operate independently with remote supervision (14%) [12].

A total of 619 patients and 367 supervisees were included (Table 3). Two studies included supervisees who were physicians, including an ophthalmic surgeon from a foreign country (14%) [9] and a general practitioner in a rural hospital (14%) [8]. Five studies included supervisees who were medical trainees, such as ophthalmology residents (43%) [7, 11, 13], vitreoretinal fellows (14%) [12], and emergency medicine (EM) residents (14%) [10].

Study setting varied between the ED [5, 7, 10, 11], operating room (OR) [9, 12], rural hospital [8], and eye clinic [13]. Virtual supervision was used for a clinical examination in three studies (43%) [7, 11, 13], surgical procedure in three studies (43%) [9, 10, 12], and in-office procedure in one study (14%) [8]. For studies involving a surgical or in-office procedure, VS was used to teach surgeons endoscopic laser-assisted dacryocystorhinostomy (ELA-DCR) [9], perform orbital decompression on a patient with extensive facial trauma [10], remove a corneal foreign body and rust ring in a rural hospital [8], and supervise retina fellows repairing macula-on rhegmatogenous retinal detachments (RRD) during bank holidays and weekends [12].

**Table 1** Search strategy

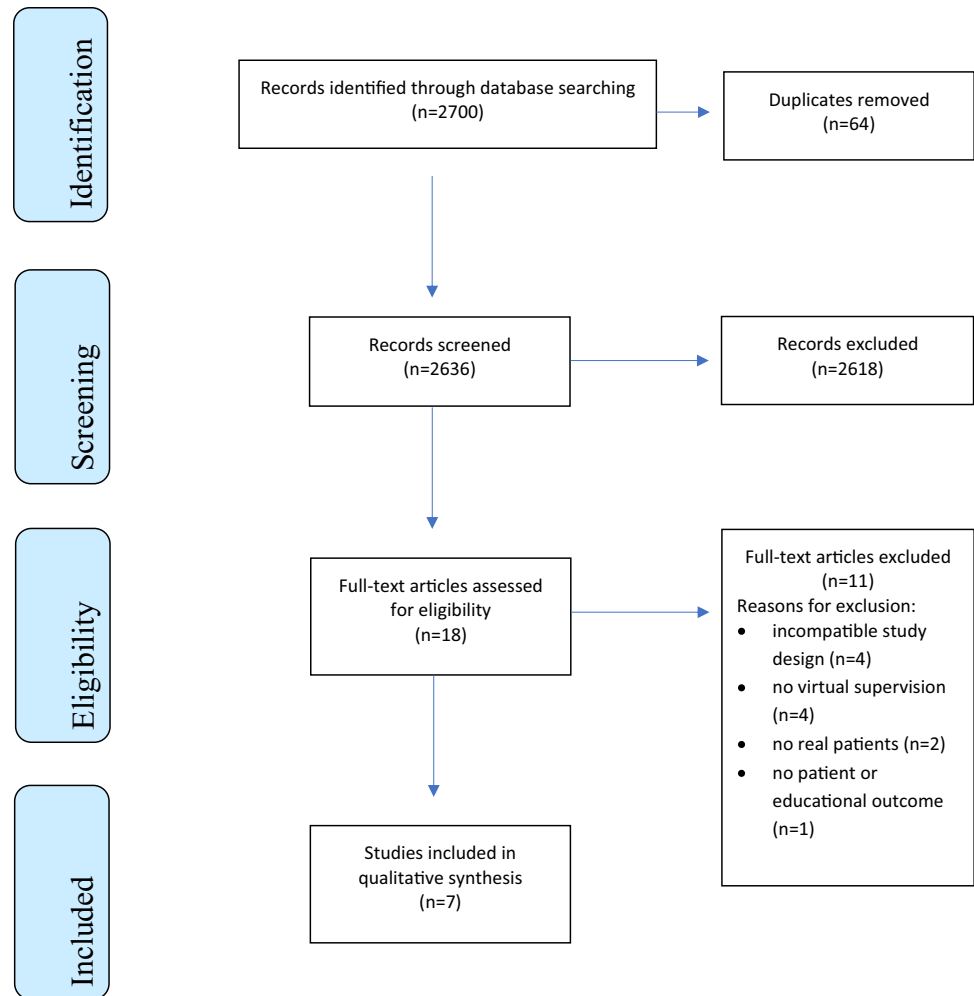
Database	Search Query
Pubmed	((("Ophthalmology"[MeSH Terms] OR "Ophthalmologic Surgical Procedures"[MeSH Terms] OR "ophthalm*" [Text Word]) AND ("Internship and Residency"[MeSH Terms] OR "education, medical, graduate"[MeSH Terms] OR "Preceptorship"[MeSH Terms] OR "medical staff, hospital"[MeSH Terms] OR "hospitals, teaching"[MeSH Terms] OR "residen*" [Text Word] OR "house officer" [Text Word] OR "trainee*" [Text Word] OR "fellow*" [Text Word] OR "house staff" [Text Word] OR "registrar*" [Text Word] OR "attending physician" [Text Word] OR "intern*" [Text Word] OR "consultant*" [Text Word] OR "postgraduate" [Text Word] OR "post-graduate" [Text Word] OR "preceptor*" [Text Word] OR "clinical supervis*" [Text Word] OR "supervis*" [Text Word]) AND (((("virtual*" [Text Word] OR "remote*" [Text Word] OR "online*" [Text Word] OR "tele*" [Text Word] OR "video*" [Text Word] OR "digital*" [Text Word] OR "web" [Text Word] OR "computer*" [Text Word]) AND ("consult*" [Text Word] OR "exam*" [Text Word] OR "conferen*" [Text Word] OR "supervis*" [Text Word] OR "monitor*" [Text Word] OR "assess*" [Text Word] OR "evaluat*" [Text Word] OR "procedure" [Text Word] OR "surg*" [Text Word] OR "visit*" [Text Word] OR "teach*" [Text Word] OR "instruct*" [Text Word] OR "direct*" [Text Word] OR "train*" [Text Word] OR "care" [Text Word])) OR ("education, distance" [MeSH Terms] OR "Internet-Based Intervention" [MeSH Terms] OR "Internet Use" [MeSH Terms] OR "Computers" [MeSH Terms] OR "computers, handheld" [MeSH Terms] OR "Smartphone" [MeSH Terms] OR "cell phone" [MeSH Terms] OR "mobile applications" [MeSH Terms] OR "Videoconferencing" [MeSH Terms] OR "Video-Assisted Techniques and Procedures" [MeSH Terms] OR "Video-Assisted Surgery" [MeSH Terms] OR "Webcasts as Topic" [MeSH Terms] OR "videotelephon*" [Text Word]))) AND (english[Filter]))
Ovid medline	((("Ophthalmology or "Ophthalmologic Surgical Procedures").sh. or ophthalm*.tw.) AND ("Internship and Residency" or "education, medical, graduate" or Preceptorship or "medical staff, hospital" or "hospitals, teaching").sh. or (residen* or "house officer" or trainee* or fellow* or "house staff" or registrar or "attending physician" or intern* or consultant or post-graduate or "post-graduate" or preceptor* or "clinical supervis*" or supervis*).tw.) AND (((("virtual* or remote* or online* or tele* or video* or digital* or web or computer*) and (consult* or exam* or conferen* or supervis* or monitor* or assess* or evaluat* or procedure or surg* or visit* or teach* or instruct* or direct* or train* or care)).tw.) or (("Education, distance" or "Internet-Based Intervention" or "Internet Use" or Computers or "computers, handheld" or Smartphone or "cell phone" or "mobile applications" or Videoconferencing or "Video-Assisted Techniques and Procedures" or "Video-Assisted Surgery" or Webcast or "Webcasts as Topic").sh. or videotelephon*.tw.))
Embase	((('ophthalmology'/exp OR 'ophthalmology education'/exp OR 'ophthalmology surgery'/exp) OR ophthalm*:ti,ab,kw) AND (('residency education'/exp OR 'interns'/exp OR 'internship'/exp OR 'medical education'/exp OR 'medical education training'/exp OR 'resident'/exp OR 'graduate medical education'/exp OR 'preceptor'/exp OR 'attending physician'/exp OR 'clinical supervision'/exp OR 'medical staff'/exp OR 'house officer'/exp OR 'teaching hospital'/exp) OR (residen*:ti,ab,kw OR 'house officer':ti,ab,kw OR trainee*:ti,ab,kw OR fellow*:ti,ab,kw OR 'house staff':ti,ab,kw OR registrar:ti,ab,kw OR 'attending physician':ti,ab,kw OR 'clinical supervis*':ti,ab,kw OR intern*:ti,ab,kw OR consultant:ti,ab,kw OR postgraduate:ti,ab,kw OR 'post-graduate':ti,ab,kw OR preceptor*:ti,ab,kw OR supervis*:ti,ab,kw))) AND (('telemedicine'/exp OR 'distance learning'/exp OR 'web-based intervention'/exp OR 'web conferencing'/exp OR 'online social network'/exp OR 'internet use'/exp OR 'internet'/exp OR 'computer'/exp OR 'mobile application'/exp OR 'handheld device'/exp OR 'smartphone'/exp OR 'mobile phone'/exp OR 'social media'/exp OR 'videoconferencing'/exp OR 'video assisted technique'/exp OR 'video assisted surgery'/exp OR 'simulation based medical education'/exp) OR ((virtual*:ti,ab,kw OR remote*:ti,ab,kw OR online*:ti,ab,kw OR tele*:ti,ab,kw OR video*:ti,ab,kw OR digital*:ti,ab,kw OR web:ti,ab,kw OR computer*:ti,ab,kw) AND (consult*:ti,ab,kw OR exam*:ti,ab,kw OR conferen*:ti,ab,kw OR supervis*:ti,ab,kw OR monitor*:ti,ab,kw OR assess*:ti,ab,kw OR evaluat*:ti,ab,kw OR procedure:ti,ab,kw OR surg*:ti,ab,kw OR visit*:ti,ab,kw OR teach*:ti,ab,kw OR instruct*:ti,ab,kw OR direct*:ti,ab,kw OR train*:ti,ab,kw OR care:ti,ab,kw))) AND (english/lim) AND ('article'/it OR 'article in press'/it OR 'conference paper'/it)
Web of Science	("ophthalm* (Topic)") AND ("residen* or "house officer" or trainee* or fellow* or "house staff" or registrar or "attending physician" or intern* or consultant or postgraduate or "post-graduate" or preceptor* or "clinical supervis*" or supervis* (Topic)") AND ((("virtual* or remote* or online* or tele* or video* or digital* or web or computer*) and (consult* or exam* or conferen* or supervis* or monitor* or assess* or evaluat* or procedure or surg* or visit* or teach* or instruct* or direct* or train* or care))
CINAHL	AB ("ophthalm*") AND AB (residen* or "house officer" or trainee* or fellow* or "house staff" or registrar or "attending physician" or intern* or consultant or postgraduate or "post-graduate" or preceptor* or "clinical supervis*" or supervis*) AND AB ((("virtual* or remote* or online* or tele* or video* or digital* or web or computer*) and (consult* or exam* or conferen* or supervis* or monitor* or assess* or evaluat* or procedure or surg* or visit* or teach* or instruct* or direct* or train* or care))

Devices used for VS included an optical coherence tomography (OCT)/fundus camera [7], slit lamp camera [8, 11], network camera [13], and ceiling-mounted camera (Table 4) [10]. Synchronous communication between the supervisor and supervisee was facilitated through various

modalities such as email [11], telephone [11], video conferencing software [8, 9], and local area network (LAN) [13].

Four studies reported successful transmission of real-time video of surgical or in-office procedures [8–10, 12, 13]. In three studies on VS for clinical examinations, supervisees

**Fig. 1** PRISMA\* flow diagram. PRISMA-ScR, Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews



held synchronous communication with their supervisors to reach an agreement in diagnosis [7, 11, 13]. Studies noted that VS was helpful for diagnosing ocular surface, anterior segment, and macular diseases but difficult to use when diagnosing vitreous and peripheral retinal conditions [11, 13].

One study noted that the slit lamp camera was sufficient to provide high enough real-time image quality for procedures [8], while another study using a network camera noted decreased transmission rate due to electronic traffic [13]. Several studies also noted machine malfunction, image artifacts, insufficient image resolution, and lighting problems as factors that decreased the effectiveness of VS [7, 11, 13].

One study reported patient outcomes related to VS and found no significant difference in 6-month retinal re-detachment rate when comparing remotely supervised to unsupervised fellows performing RRD repairs on bank holidays and weekends [12].

Only one study reported educational outcomes. In this study, four out of eight residents stated that VS helped them

diagnose patients more accurately, as they could synchronously share the images with the supervisor and talk through their thought processes [7].

### Critical appraisal of included studies

The MMAT was used to critically appraise the quality of the studies. Limitations were noted in outcome measurement [8, 9], statistical analysis [8–10], sampling strategy [11, 13], and inclusion of confounding factors [11, 13]. Overall, two studies scored a 5/5 [7, 12], one study scored a 4/5 [10], and four studies scored a 3/5 [8, 9, 11, 13].

### Discussion

There is a limited evidence base on VS in ophthalmology. The few available studies suggest that VS is technologically feasible, may provide a positive experience for both supervisees and patients, and can permit synchronous

**Table 2** Characteristics of included studies

Study, year	Location	Study design	Study design (timing)	Primary objective	Secondary objective
Shah 2022	USA	Case report/series	Both prospective and retrospective	To describe the initial implementation of a teleophthalmology tool in the emergency department	To describe impact of the teleophthalmology tool resident education
Hall 2005	Australia	Case report/series	Prospective	To evaluate whether the removal of corneal foreign bodies and rust rings can be effectively supervised via teleophthalmology	Not reported (NR)
Camara 1998	USA and Philippines	Case report/series	Prospective	To determine the feasibility of real-time surgical telementoring for complex ophthalmologic procedures in remote areas	NR
Hagman 2004	Europe other than UK	Cross-sectional study	Prospective	To test the feasibility of a network camera in a real-time teleconsultation in eye care	NR
Bar-Sela 2007	Israel	Cohort study	Prospective	To examine the feasibility of using a low-bandwidth, internet-based teleophthalmology system for resident-senior consultation in the ophthalmic emergency room	To determine whether the teleophthalmology system would improve the assessment of complicated cases
Moussa 2022	UK	Cohort study	Retrospective	To determine whether first and second-year fellows could safely operate out-of-hours independently with remote supervision on primary macula-on rhegmatogenous retinal detachments	NR
Wilson 2020	Australia	Case report/series	Prospective	To describe teleophthalmology supervision of an emergency orbital decompression	NR

**Table 3** Detailed characteristics of included studies

Study, year	Setting	Supervisee type	Patient ( <i>n</i> )	Supervisee ( <i>n</i> )	Type of procedure
Shah 2022	Emergency department	First-year ophthalmology residents	109	10	Clinical exam
Hall 2005	Rural hospital	General practitioner	2	2	In-office procedure
Camara 1998	Operating room	Ophthalmic surgeon	1	Not reported	Surgical procedure
Hagman 2004	Ophthalmology department/eye clinic	Ophthalmology resident	22	2	Clinical exam
Bar-Sela 2007	Emergency department	Ophthalmology resident	49	1	Clinical exam
Moussa 2022	Operating room	First- and second-year vitreoretinal fellows	435	351	Surgical procedure
Wilson 2020	Emergency department	Emergency medicine resident	1	1	Surgical procedure

communication and transmission of clinical data, which can be used to formulate diagnosis and management plans or learn new surgical skills.

Virtual supervision can improve diagnostic accuracy by allowing fast, synchronous communication between supervisor and trainee. In one study, ophthalmology residents (training level unspecified) used VS to consult their supervisors regarding complicated cases during night shifts in the ED [11]. The residents communicated with their supervisors via telephone and emailed images and videos captured by a miniature slit lamp camera. The authors found high agreement in diagnosis made during the night shift and the on-site examination by the supervisor the next day. In another study, first-year ophthalmology residents sent OCT/fundus photographs to the supervisor to synchronously discuss a differential diagnosis [7]. The use of the device did not correlate with a longer duration of visit in the ED.

Virtual supervision can also impact ophthalmic surgical GME. In one study, retina fellows who were deemed ready to operate independently by their supervisors performed surgery while supervisors provided synchronous feedback from a remote location during holidays and weekends [10, 12]. This readiness was assessed on a case-by-case basis by the supervisors after 2–3 months of supervised training based on a review of recorded surgeries and didactics. The study included only primary uncomplicated macular RRDs; patients with more complex retinal detachments were excluded. The study reported no statistical difference in the 6-month retinal re-detachment rate between off-hour cases utilizing VS and off-hour cases without any supervision. The authors did not mention if there were any adverse events, difficulties with VS, or a safety plan if a significant complication were to occur during the surgery.

In addition, ophthalmologists can use VS to assist physicians in areas with limited access to ophthalmic care or continuing medical education (CME). In one study, a general practitioner in a remote area provided time-sensitive ophthalmic procedures with the assistance of synchronous communication with ophthalmologists [8]. In another study,

ophthalmologists in the USA were able to teach a new procedure to ophthalmologists in the Philippines who had the necessary equipment but not the surgical expertise [9].

This review suggests that various methods can be used to ensure high image and video quality during VS, although challenges remain. In one study, patients were instructed to keep voluntary movements to a minimum and to fixate on a target, and a designated remote operator kept the slit lamp image focused [7]. Despite these methods, there were technological glitches, image artifacts, and internet connection issues. Most studies reported that quality of images and videos were adequate for clinical diagnosis and procedure guidance, although in some cases, supervisees needed to spend a significant amount of time to find the optimal setup [11, 13]. Furthermore, the blue filter on the slit lamp with fluorescein was particularly difficult to visualize during VS due to degradation of the video quality [7].

We identified several gaps in the literature on the use of VS in ophthalmology. First, most studies on ophthalmic GME lacked standardized curricula to implement the interventions and methodology to assess the outcomes. Surveys were often used to assess feasibility and usability of VS; only one study collected data from all supervisors, supervisees, and patients [11]. Furthermore, no studies included control groups, which makes it difficult to compare the effectiveness of VS versus direct supervision in GME. Second, most studies focused on feasibility of technology for VS rather than on clinical or educational outcomes. One study that assessed educational outcomes relied on self-reported data without a comparison group [14]. Third, there was significant heterogeneity in the types of supervisees such as residents, fellows, general practitioners, and physicians. Supervisees have varying needs based on their background and training experience, which makes it difficult to generalize the results [15].

This review has several limitations. First, we did not include studies published in gray literature or in languages other than English. Second, the reproducibility of MMAT

**Table 4** Interventions, outcomes, and MMAT rating of studies

Study, year	Intervention	Primary outcome	Secondary outcome(s)	MMAT rating
Shah 2022	Topcon 3D optical coherence tomography (OCT)-1 maestro	Most residents expressed that the imaging system held educational value and helped them diagnose patients more accurately	The device was comfortable for patient usage, although residents sometimes experienced machine malfunction and image artifacts	*****
Hall 2005	Slit lamp camera (Sony DXC 950) video conferencing software (Apps View by VTEL) static high-resolution images from the slit lamp camera (i-PIX by Designs for Vision) ISDN network	Corneal foreign body removal was possible using teleophthalmology	Slit lamp cameras provided sufficient real-time image quality for supervising physicians to guide ophthalmic procedures	***ab
Camara 1998	PictureTel videoconferencing system with digital camera and integrated systems digital network (ISDN) line (128 kbps)	Using live video, supervisors in Hawaii telemonitored supervisees in the Philippines on an endoscopic laser-assisted dacryocystorhinostomy	Not reported (NR)	*** ab
Hagman 2004	Network camera (Sony SLC-VL10 network camera) and local area network (LAN) compared to videoconferencing equipment widely used in telemedicine (Tandberg 880)	Majority of clinical findings were detected through the network, although fundus examination was more difficult	Main problems included PC malfunction, decreased transmission rate due to electronic traffic, and movement of the patient	***c,d
Bar-Sela 2007	A miniature video camera attached to a slit lamp bio-microscope with a beam-splitter attachment, background illumination coaxial with the slit lamp light, communication via email and telephone	There was a high degree of agreement in diagnosis made by the resident and the senior ophthalmologist	The video camera was best for ocular surface, anterior segment, anterior chamber angle, pupils, lens, posterior pole, and macula cases but difficult for vitreous and peripheral retina cases	*** c,d
Moussa 2022	Watching the operation on the screen	The rate of success of rhegmatogenous retinal detachment by vitreoretinal fellows was similar whether supervised in-person or virtually.	Most patients preferred being examined via telemedicine system on their next emergency room visit	*****
Wilson 2020	Ceiling-mounted camera and teleconference	An ophthalmologist was able to successfully supervise an emergency department trainee and physician to perform orbital decompression	Initial supervision, feedback, and training are needed for fellows to develop independence as surgeons	***** b

a, Lack of appropriate outcome measurement; b, lack of appropriate statistical analysis; c, limitation in sampling strategy; d, limitation in accounting for confounding factors



ratings is limited by the authors' judgments about the quality of the study design.

In conclusion, this scoping review highlights the potential utility of VS in ophthalmology and identifies areas for future research on this topic. Recent technological advancements allow supervisors to guide other physicians and trainees through VS, with potentially improved efficiency and collaboration between different institutions and countries. Future studies should employ larger sample sizes and more rigorous methodology to better define the safety and efficacy of VS in ophthalmic practice and education [16].

## Declarations

**Conflict of interest** The authors declare no competing interests.

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