Review article

Implementation of Telemedicine in Otorhinolaryngology

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Abstract

Telemedicine is a term that covers all procedures supported by communication technology, which has the purpose of providing health services at a specific spatial distance. This is an area that is developing rapidly and has found particular application in otorhinolaryngology, given that a large number of surgeries are performed with the help of endoscopes and microscopes. Telemedicine also represents a significant advantage during the coronavirus pandemic, both in terms of treating patients and monitoring them more effectively. For the purpose of preparing this article, research published on Scopus, PubMed, Google Scholar, and Google was reviewed using the keywords "telemedicine" and "otorhinolaryngology". This review article provides a summary and the latest insights in this broad and fast-growing area. The development of telemedicine in Croatia as well as a special review of the application of telemedicine during the coronavirus pandemic is also presented in this article.

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Introduction

Telemedicine is a term that covers all procedures supported by communication technology, which has the purpose of providing health services at a specific spatial distance. The concept of telemedicine includes various activities, such as teleassistance, telemonitoring, teleconsultation, tele-expertise, videoconferencing, and telesurgery (1). These are the most common terms, although standardised terminology is missing due to a very rapid development of telemedicine (2,3). The goal of all these activities is to increase the quality of health care and make health care available to every patient at any place. Telemedicine is a rapidly evolving field that has provided much more efficient access to patients. Telemedicine has been applied in many specialties, including otorhinolaryngology.

For the purpose of preparing this review article on the application of telemedicine in otorhinolaryngology and the latest knowledge in this field, research published on Scopus, PubMed, Google Scholar, and Google was reviewed using the keywords "telemedicine" and "otorhinolaryngology". Abstracts of relevant articles were studied and based on relevant data, full texts of the papers were reviewed. Considering that telemedicine in otorhinolaryngology is heterogeneous, the review article is divided into several parts depending on the field of otorhinolaryngology concerned.

History of telemedicine and its development in Croatia

In the 1960s, NASA sent humans into space as part of the Apollo project. Astronauts should be medically protected in different conditions – this was the beginning of biomedical observation development (4-7). As there was a need for connection and astronauts' mutual education, NASA played a significant role in telemedicine development due to its ability of establishing satellite links. The first complete telemedicine system was installed in 1967, connecting the Boston Airport medical station with the Massachusetts General Hospital. In 1989, NASA conducted the first international telemedicine project, Space Bridge to Armenia, following a strong earthquake in Armenia in 1988 (8).

The first steps in the development of telemedicine in Croatia were made in the 1980s, when an ECG was recorded based on a distant patient's first message at the Clinic for Cardiovascular Diseases in Zagreb. The cardiologist received the imaging record and interpreted it. The technology of the time was not able to transmit mutual, simultaneous change of image and sound. Progress was made after the development of ISDN networks and establishment of the government agency Croatian Academic and Research Network (CARNet) in 1991/1992. In 1993, a national telepathology system with remote hospital centres was established in Zagreb. In 1995, a program was launched to monitor people with diabetes across the country. In the following year, a telecommunication program for cardiac electrostimulation was presented, and in 1998, the national teleradiology and teleneurosurgery programs were in full function. In the same year, the Croatian Academy of Medical Sciences organised a scientific conference on Croatian telemedicine achievements to encourage cooperation between outpatient facilities and higher health system levels. Three years later, central institutions made connections with some islands. During this period, large medical centres developed numerous tele-education programs (9).

Almost every clinical specialty uses telemedicine in a certain way, but some specialties use it to a greater extent than others. Radiologists, for example, use telemedicine extensively. The teleradiology system electronically transmits radiological images and image descriptions. By transferring the image to the radiologist, he can interpret the radiological images very quickly. After NASA, another essential factor in the development of telemedicine was the military.

In the academic year 2009/2010, the Faculty of Medicine in Osijek recognised the importance of knowing the basics of telemedicine, thus

introducing it as a course in the compulsory elective module (Clinical Medicine) as part of the Postgraduate Doctoral Study Programme of Biomedicine and Health. The course consists of 18 lecture classes and 12 seminar classes and over 40 students enrolled in this elective course in the last two generations.

The timeline of the development of telemedicine in Croatia and the world is shown in Figure 1.

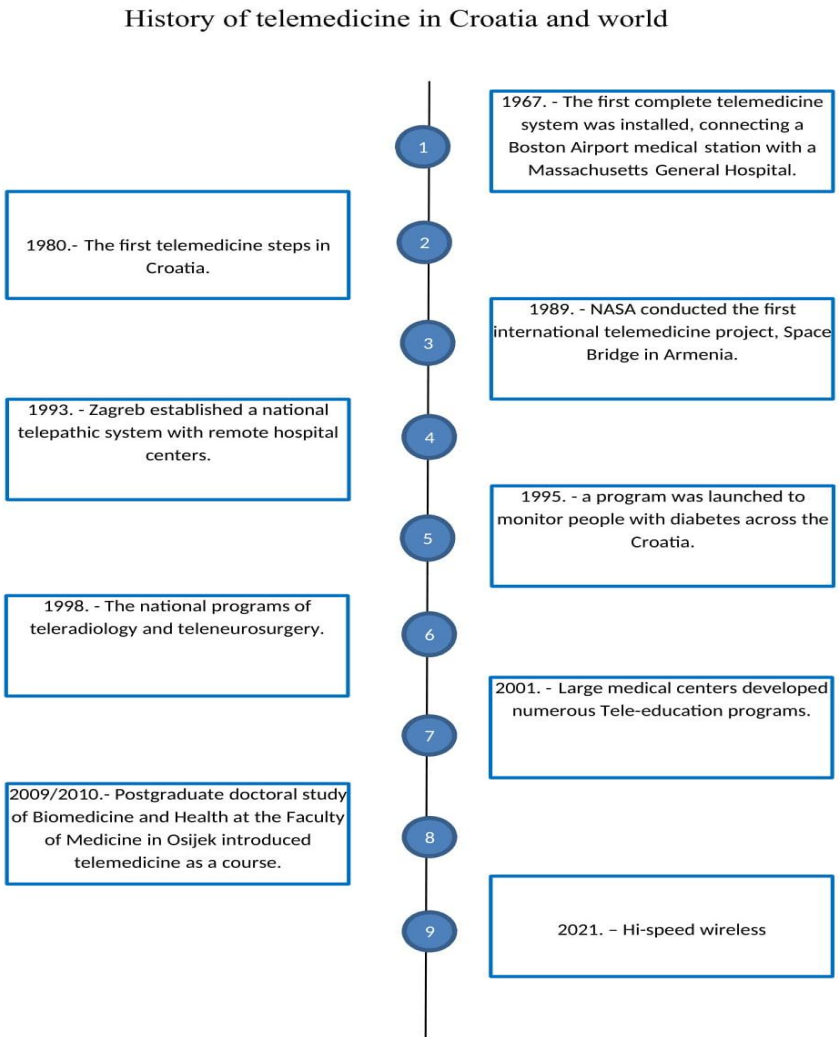

Figure 1. Timeline of telemedicine development in Croatia and the world

Potential of telemedicine development with the development of 5G network

The 5G technology is increasingly mentioned as a driving force of the fourth industrial revolution due to its characteristics and the possibilities it opens up. 5G is as important to humanity as was the invention of the steam engine in the first industrial revolution, the emergence of electricity and oil-powered devices in the second industrial revolution, and the emergence and spread of the Internet in the third industrial revolution. The most important advancements that the 5G technology brings to communication are fast and reliable data transfers, extremely low latency, coverage, and energy efficiency required for such data transfer (10).

The 5G technology improves communication in three main areas using the so-called "5G triangle" consisting of (11): • uRLLC: Ultra-

Reliable Low Latency Communication use cases; • mMTC: Massive Machine Type Communication (IoT) use cases; • eMBB: Enhanced Mobile Broadband – high-speed use cases. The technology called Ultra-Reliable Low Latency Communications (URLLC) brings improvements in the field of healthcare because it is extremely reliable in terms of communication continuity and has a very low response rate, which can be around five milliseconds or less (11).

The latest example of a successful implementation of this technology was given by the Istituto Italiano di Tecnologia in Italy (12), where it was used on the body of a deceased person using robotic technology controlled via a 5G network. The procedure was performed in a manner that the surgeon effectively controlled the surgical robot, forceps, and laser and successfully performed a high-precision laser cordectomy as if he were physically present in the operating room. Surgeries used to be limited due to unreliable and limited networks, which is a problem that the 5G network solves. In this case, it has been proven that a broader implementation of this technology is possible (12).

In addition to surgery, the 5G network will enable fast and reliable transmission of the Internet of Things, which is a network of physical objects consisting of wireless sensors and portable mini-computers that collect data. Such data will be stored in real time due to cloud computing, which provides computing services such as servers, storage, databases, networking, software, analytics, and intelligence (10).

Conditions for the application of telemedicine technology

The biggest advantage of using telemedicine pertains to rural areas and areas of the world where there is a shortage of physicians (13,14). However, certain prerequisites are also required for telemedicine to be used. The application of telemedicine technology primarily depends on the development of telecommunication infrastructure and the relationship between institutions that provide specialist knowledge. At the moment, the most popular approach is based on the "hub-and-spoke" model, in which communications are established between an outpatient department (spoke) and specialist (hub) health care (15). The primary purpose of this model is to have a direct connection between an outpatient department and secondary health care in which there is direct communication between the patient, general practitioner and specialist. Additionally, all sorts of online applications can also provide essential information about the patient and medical data. The fundamental principle is to gather all information we can about a patient in the spoke centre, which is then transferred to a hub centre specialist. This is the point where consultation begins. A primary health care centre must have medical equipment necessary to gather medical information and certain communication equipment, while specialists should only have multimedia equipment at their disposal. Primary health care clinicians should have basic biometric instruments, such as thermometers, pressure gauges, oximeters, and ECG devices. Only with these instruments can we gather important information required for monitoring the patients' condition. Besides biometrics, telemedicine uses all kinds of telemedicine applications that utilise advanced technology to provide static images and videos. Using such interactive technology, we can ensure direct audio-visual communication and transfer static images, such as RTG, CT, or MR scans. It is precisely this technology that enables the classification of telemedicine into tele-education, teleconsultation, telediagnosis, and telemonitoring (15). All of this is important because telemedicine provides telepresence, 3D visualisation and remote control supervision of patients, and better sharing of medical knowledge, which ultimately improves health care for patients.

One of the main limitations of telemedicine in otorhinolaryngology and other medical fields is the need not only for the diagnosis of the disease, but also for treatment (16). Therefore, for some cases when an examination is required, a portable haptic system that transmits a

palpatory impression has been developed, or ultrasound can be used (17,18).

Factors affecting the further development of telemedicine

Telemedicine has proved to be one of the most promising medical branches, with an ongoing increase in distribution worldwide (1). However, it still has not reached its full potential due to many significant reasons. One of the most critical problems regarding telemedicine distribution is the cost of telecommunication infrastructure and technology. Sophisticated telemedicine devices are often over the budget of many hospitals all over the world, especially the ones from developing countries (1).

Secondly, to establish high-quality telemedicine communication with other medical centres worldwide, medical staff should undergo a proper training that will get the best out of the technology that will be used. It is essential to understand the complexity of medical staff involved in telemedicine projects – from physicians, nurses, and technicians to health managers, health administrators, and medical computer scientists. It is easy to conclude that providing these specific groups with training will also take time and funds.

Unfortunately, even when the highest standards in securing top-quality equipment and education for telemedicine are met, one cannot ignore a cultural factor in telemedicine distribution. Many countries do not want to take advantage of modern medicine and are ignorant of creativeness, innovation, and diverse approaches to modern medical issues. If this factor changes over time, there will be significant advancements in modern medicine. Other crucial aspects that most people do not take into account when discussing the factors affecting telemedicine distribution are legal boundaries, which differ from one country to another. For example, some of the United States of America's legal boundaries restrict providing medical services outside of the country (1). Therefore, it would not be legally possible to provide essential medical information to a specific country in Europe that could help in a patient's treatment outside the US. Furthermore, distant telemedicine communication should not result in compromising and disclosing a patient's private information, which is one of the most critical patient's rights.

Because of the numerous advantages that modern telemedicine offers, the highest priority of every country should be to create stable and top-quality medical centres that provide telemedical services and to make them a reference centre. In order to achieve that, every country should have an assessment team, which would be in charge of the evaluation of certain medical centres in order to provide top medical services. Unfortunately, most countries still have infrastructural and organisational limitations in that regard.

Even though there are various problems regarding telemedicine distribution, it is important to emphasise that telemedicine is growing increasingly in the entire world. With high motivation and acceptance of different ideas, telemedicine could be very successful in the future.

Special review of the use of telemedicine during the coronavirus pandemic

COVID-19 disease is a viral infection caused by the coronavirus named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The disease spread quickly across the globe. SARS-CoV-2 transmission occurs via respiratory droplets produced by infected individuals while talking, sneezing, or coughing without covering the mouth and the nose (57). Minimising the virus transmission has become a critical part of patient care during the COVID-19 pandemic. Telemedicine is indeed advantageous in that regard as it prevents person-to-person contact, thus ensuring social distance, and it is therefore recommended by various health agencies for COVID-19 (58). Fortunately, telemedicine is not new to otorhinolaryngologists, so it can be applied in real-time delivery and monitoring of services via video conferencing (synchronous care). On the other hand, there is a store-and-

forward methodology, where test results are stored and reviewed later (asynchronous care). These evaluations have been proven useful for plastic postoperative evaluation, head and neck oncology, facial trauma evaluation, triaging and postoperative visits, allergic or non-allergic rhinitis management, endoscopic sinus surgery, postoperative evaluation, and vocal rehabilitation. The COVID-19 pandemic has propelled telemedicine necessity and utilisation into the mainstays of current otorhinolaryngology practice (59).

Application in audiology

Audiologists have the opportunity to provide services to those who may otherwise have no access to much-needed care, from those in rural areas to patients with limited physical mobility (19). Hearing aid services, such as counselling, fitting, and device testing can be provided through telemedicine. Lack of high-speed Internet connections and limited bandwidth in some rural locations could prevent the delivery of some services (20). Telemedicine in audiology can be applied in real-time delivery and monitoring of services via videoconference. On the other hand, there is a store-and-forward methodology, where test results are stored and reviewed later. Likewise, telemedicine in audiology has been applied in providing education and training to professionals, hearing screening, diagnosis, and intervention (21). Small fitting of hearing aids is possible via the Internet. The technological approach can help with hearing rehabilitation, as patients can ask for help from the comfort of their own homes (22).

Furthermore, teleaudiometry is a reliable, valid, and viable option for hearing tests. Results can be analysed by experts remotely. Moreover, teleaudiometry reduces the costs of hearing screening programs (23). Telemedicine in audiology opens access to vital hearing care.

Telemedicine in Phoniatrics and Phonosurgery

Phoniatrics is a branch of otorhinolaryngology that studies, diagnoses, and deals with voice, speech, language, and swallowing disorders and diseases. The application of telemedicine in phoniatrics and phonosurgery is continuously growing and it can be an essential tool in certain medical situations, such as stuttering or dysphonia (1). The possibility of consulting with colleagues via web conference technology can sometimes be crucial in patient treatment options. According to some reports, around 12% of all speech therapies and assessments in India were performed via telemedicine (1)!

The most important aspect of presenting a phoniatric patient via remote stroboscopy and laryngoscopy is high video and audio recording quality. Higher quality of the footage will provide precise visual and auditory information about particular laryngeal pathology and facilitate physicians' decision about treatment. Furthermore, telemedicine can be essential in voice rehabilitation. It allows for direct consultations with experts across the world on certain phonological issues and provision of optimal healthcare to a patient by eliminating the barriers of time and space.

A fascinating and successful example of telemedicine usage in phoniatrics is the Camperdown Program, a therapeutic approach in the treatment of stuttering (24-27). This therapeutic approach showed no significant difference in curing stuttering telematically in comparison to the in-person approach (28-31). This is only one of many examples highlighting telemedicine as one of the most critical and trustworthy approaches in modern phoniatrics.

Unfortunately, the cost of sophisticated technology and its complexity, which requires trained personnel, are often a limiting factor for a vast number of otorhinolaryngology departments.

However, every medical professional should look forward to dealing with current barriers with a great deal of optimism and motivation to improve every aspect of telemedicine and make it available to every single part of the world.

Application in rhinology

Numerous studies have proven that telemedicine consultation can be applied in rhinology as well. Setzen et al. pointed out that it is possible to triage patients who need to undergo nasal endoscopy by taking a medical history through telemedicine, but this requires guidelines that need to be determined in the future (32). Patients with unilateral sinonasal symptoms and patients with radiologically proven unilateral sinonasal diseases need repeated medical check-ups after nasal endoscopy via telemedicine. Also, during the COVID-19 pandemic, high-risk, immunocompromised patients present a challenge. Telemedicine allows such patients to stay at home during their first examination. In immunocompromised patients, nasal endoscopy should be indicated at the onset of new symptoms, such as severe pain, fever, and other general symptoms (32). When it comes to ENT, patients' condition can be assessed by telemedicine by radiological images (X-ray, CT) and endoscopic images, which can be qualitatively transmitted to distant places. Telemedicine technology has made rapid progress in the last 20 years in terms of the quality of equipment, better internet connectivity, and better image sharing software. In ENT, synchronous telemedicine is also being developed, which has significant advantages over older methods (33,34).

Nasal endoscopy is a high-risk test due to a potential exposure of the examiner to a COVID-19 infection. Also, anaesthetic sprays have aerosol potential, which increases the risk of infection transmission, both by direct contact and indirectly. As numerous studies have shown a correlation and concordance in the evaluation of sinus disorders between CT and nasal endoscopy, CT of the paranasal sinuses represents an interesting alternative to nasal endoscopy (35). Another alternative is intranasal imaging, where, for instance, video files can be sent to a remote device (36). Epistaxis is a common disorder in rhinology, which may be adaptable for a remote evaluation. Telemedicine can help detect trigger risk factors and help cure minor bleeding. A history of uncontrolled bleeding, despite conservative measures provided, requires a prompt live evaluation. In rhinology, telemedicine may also play a role in a postoperative follow-up of patients after a nasal septal surgery and a functional endoscopic sinus surgery (32).

Telemedicine is being developed and is useful in skull base surgery. Telementoring is widely applicable in skull base surgery, in endoscopic endonasal surgery for the surgical treatment of diagnoses such as benign and malignant neoplasms, cerebrospinal fluid leak, and inflammatory diseases. This technology requires two-way real-time video and audio communication using the existing technology. An expert who is not present in the operating room and a surgeon communicate using telemedicine technology and they have robotic technology available to visualise the operating field. Also, with the help of a laser pointer, orientation can be assisted (37).

Application in head and neck oncology

Telemedicine is widely applicable in surgical head and neck oncology. In this area of otorhinolaryngology, the application of telemedicine results in better patient follow-ups, better collaboration among physicians, reduction of unnecessary patient's transfer to specialist facilities, and reduction of patient travel costs (38-41). Kohlert et al. show that 48.6% of consultations in otorhinolaryngology account for head and neck oncological surgery (42). A study from the USA conducted by Prasad et al. describes a virtual examination of patients with head and neck cancer, aiming to set out guidelines for each specific tumour site for the best follow-up possible (43). While extremely useful, this approach can be challenging for both the physician and the patient, mainly because it concerns a new clinical evaluation model for both parties. Head and neck cancer surveillance is often challenging to perform in person, and doing this virtually is even more difficult (38,44).

A multidisciplinary team participates in treating an oncology patient and communication and cooperation between team members are improved using real-time video conferencing (45-49). Also, this form of communication

between multidisciplinary team members has been applied during the COVID-19 virus pandemic due to the inability to gather team members in one place. In addition to real-time video conferencing, communication can be established using various communication platforms. Rimmer et al. stated that for some patients, postoperative telemedicine monitoring is relatively safe and saves time (48). Also, during the COVID-19 epidemic at our institution, psychological counselling was provided to oncology patients by phone, which according to some studies had a positive effect on this type of patients (50,51).

Application in palliative care

Less than a decade ago, the Worldwide Palliative Care Alliance and the World Health Organization concluded that palliative health care represents both a necessity and an essential human right (52). However, palliative care has been suffering from a significant lack of resources for years, primarily in terms of finances. The situation is further aggravated by the ongoing pandemic. Some researchers have noticed that head and neck tumours have shown some similarities with the COVID-19 infection. Regarding both conditions, resources are low, there is a shortage of time, patients' condition can quickly deteriorate, and the family needs consulting about these diagnoses (52). Therefore, the majority of head and neck tumour centres have allowed consultations with patients and their families by phone. The most important goal is to lower the number of unnecessary hospitalisations and consequently reduce the risk of a coronavirus infection for those patients. Another equally important thing is to provide secondary health care through a "hub-spoke" model, in which human empathy and a professional relationship between primary and secondary care physicians should play the key role (52). We live in the age of technology and one should make use of its resources because the definition of palliative care is to provide the best health care possible and to improve the quality of life of patients suffering from a disease in its terminal stage. This is where telemedicine comes in with its potential to improve health care to a degree which every terminal head and neck oncology patient deserves. Therefore, it is necessary to work with telemedicine technology on further development of palliative care, and in otorhinolaryngology, this primarily applies to patients suffering from head and neck cancers (53,54).

Application in sleep medicine

Obstructive sleep apnoea (OSA) is a common disease that leads to severe symptoms and comorbidities. Although general measures are essential, continuous positive airway pressure (CPAP) is the best treatment option (55). However, compliance may be suboptimal and telemedicine may play a role in improving it. To improve OSA management, there is an urgent need to develop new cost-effective strategies, especially those related to OSA treatment, from lifestyle changes to CPAP implementation. Two broad strategies should be applied: 1) appropriate pre-, peri-, and post-titration measures to ensure sufficient continuous positive airway pressure, appropriate training, and appropriate support during follow-up; and 2) use of technological advances, including the optimisation of CPAP devices and the use of telemedicine, specifically focused on the first days or weeks of treatment (55,56). Telemedicine can help with these processes, especially when tailored to each patient.

Traditional methods of diagnosis and treatment of OSA include history, clinical examination, diagnosis, counselling on the condition and treatment of the patient, patient care, and self-treatment of patients with mild or severe obstructive sleep apnoea (56). A multidisciplinary approach is required for an optimal diagnosis and treatment of patients with OSA. The neurologist, otorhinolaryngologist, and head and neck surgeon play the most important role in this multidisciplinary team. The neurologist diagnoses obstructive sleep apnoea by using polysomnography, the golden diagnostic standard. The otorhinolaryngologist tries to locate the site of airway obstruction in a patient by performing a standard clinical

examination, including awake fibre endoscopy and drug-induced sleep endoscopy (DISE). The head and neck surgeon's role is surgical treatment of the detected obstruction and consequent improvement of airflow through the upper respiratory tract. Adhering to the guidelines and best practices of treatment and follow-up of patients, there are also numerous opportunities for improvement with new technologies.

Telemedicine can improve the treatment and follow-up of patients with obstructive sleep apnoea by educating patients more efficiently and reducing the costs of treatment (56). Medical history is essential for a correct diagnosis, and it can be done by phone, video link, or e-mail consultations. Completion of surveys can also take place electronically. Measurements of body weight, BMI, height, and blood pressure can be taken at home, and the results can be sent electronically. Replacing the examination of patients, such as a specialist examination by an otorhinolaryngologist, with video call examinations is challenging. This is because the examination involves methods such as indirect laryngoscopy, fibre endoscopy, or DISE, so in this case, one-on-one examination is essential. Monitoring treatment outcomes and the condition of patients with obstructive sleep apnoea by other specialists can be facilitated by telemedicine because the CPAP device can send information about the patient and therapy given (55). As with other diseases and conditions, OSA telemedicine plays a vital role in the communication between members of a multidisciplinary team, who can share experiences, educate themselves, monitor the patient, and decide on further treatment through videoconferencing.

Conclusion

The development of telemedicine in otorhinolaryngology represents a new approach to diagnostic and therapeutic procedures. This is a rapidly evolving field, which certainly introduces some novelties into everyday practice, improves the quality and availability of medical care in areas where there is a shortage of physicians, and increases the attractiveness of otorhinolaryngology to younger colleagues. It is also necessary to point out the shortcomings of telemedicine technology – primarily expensive equipment and the need for additional staff training. In countries such as Croatia, where there is no shortage of otorhinolaryngologists and resources are limited, telemedicine can be beneficial in situations such as the COVID-19 pandemic and it can also be used for educational purposes.

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