REVIEW

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Telemedicine and Orthopedic Surgery: A Narrative Review

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SUMMARY

Purpose of review. The purpose of this paper is to review the current concepts regarding a new form of medicine which, especially in recent years, is enjoying more and more success. Especially how telemedicine can be beneficial in many areas of orthopedic clinical practice.
Recent findings. In the past, telemedicine for orthopedics was the prerogative of rural areas, where the distance from the hospital could be as much as 150 miles, to assure patients equal access to the care. In the last few years telemedicine has undergone an important boost so much that it has now routinely entered the approach to the patient. Multiple appropriate telemedicine applications are suggested for orthopedic practice, such as teleconsultation for diagnosis, treatment, and patient follow-up with a pivotal role in virtual rehabilitation.
Discussion. The fields of application of telemedicine in orthopedics range from teleconsultation to fracture management, to postoperative follow-up and above all to telerehabilitation.
Telerehabilitation is one of the fields of greatest interest in tele-orthopedics due to the possibility of providing remote rehabilitation services using digital technology, regardless their location and reducing the geographical and access barriers to the care.
Technology is evolving more and more and tele-orthopedics is also benefiting from it, thanks above all to the advent of AI which improve the accuracy of or reduce the time associated with critical diagnostic steps.
Conclusions. This trend will be confirmed, and the adoption of telemedicine practices will continue to expand because due to the necessary digital evolution that is characterizing the medical practice.

KEY WORDS

Telemedicine; orthopedics; telehealth; tele-rehabilitation; video-consultation.

INTRODUCTION

Telemedicine is a branch of telehealth defined as a digital intervention that could bring patients and practitioners closer together, allowing information exchange despite being geographically separated, using smartphones, computers or other electronic devices. WHO (World Health Organization) defined telemedicine as "healing from a distance", providing patients with healthcare consultation, monitor-

ing, and treatment services at a distance. Orthopedics, being provided both in the hospital and in the community setting, is a specialty that can benefit greatly from telemedicine. It is considered an opportunity with potential to be explored given its cost-effectiveness, for positive patient-reported outcomes (1) and for the reduction of geographical and accessibility barriers. In the past, telemedicine for orthopedics was the prerogative of rural areas, where the distance from the hospital could be as much as 150 miles (2), to assure patients equal access to the care. In 2019 the whole world is hit by the Coronavirus pandemic, closing all non-life-saving businesses (the so-called lockdown). To prevent the circulation of the virus, a travel ban is imposed, and it is precisely at this moment that telemedicine comes to the aid of practitioners. Because of COVID-19 pandemic, to address the new needs and challenges, telemedicine has undergone an important boost so much that it has now routinely entered the approach to the patient. Multiple appropriate telemedicine applications are suggested for orthopedic practice, such as teleconsultation for diagnosis, treatment, and patient follow-up with a pivotal role in virtual rehabilitation (3).

MATERIALS AND METHODS

Search strategy

The literature search of the present narrative review was conducted according to this protocol:
1) Telemedicine.
2) Linkage about telemedicine and orthopedics.
3) Telehealth, tele-rehabilitation, video-consultations.

Literature search

In March 2023 the following databases were accessed: PubMed, Embase, Scopus, Web of Science, Google Scholar. The following keywords were used in combination: telemedicine, orthopedics, telehealth, mhealth, videoconsultations, follow-up, post-operative, cost-effectiveness. If title and abstract matched the topic, the full text was accessed. The bibliographies of the full-text articles were also screened for inclusion. Disagreements were solved by a third author (FO). All the articles that investigate possible association between gut microbiota and musculoskeletal pathologies were considered. According to the authors language capabilities, articles in English, French, German, Italian, and Spanish were considered.

DISCUSSION

Based on the published literature, a review has been carried out on telemedicine and its fields of application in orthopedics. Starting from the history of telemedicine, its role in video consultation, tele-rehabilitation and post-operative management was addressed. With a view to the economic impact, a review of the actual costs was carried out.

History of telemedicine

The first historical trace of the use of telemedicine dates back to 1959, University of Nebraska established a two-way television setup to transmit information to medical students across campus, and five years later linked it with a state hospital to perform video consultations (4). In the early 1960's, due to advent of radio system, telemedicine appeared in urban communities, especially in emergency situations (5, 6). An example is given by the University of Miami School of Medicine partnered with the local fire department that in 1967 transmitted electrocardiographic rhythms over radio to Jackson Memorial Hospital in rescue situations (7). Telehealth became popular in rural areas, where populations with limited access to health care had the ability to reach specialists without leaving home. In the 1960's and 70's, the Public Health Department, NASA, the Department of Defense and the U.S. Health and Human Services Department all invested time and money for research in telemedicine. One of the most successful of these government projects was the partnership between the Indian Health Services and NASA. The project was called Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) and provided both Native Americans on the Papago Reservation in Arizona and astronauts in orbit with access to medical care. Microwave technology transmitted X-ray photographs, electrocardiographs, and other medical information to and from the Public Health Service hospital. Innovative projects like STARPAHC spurred research in the field of medical engineering, leading to quick growth for telemedicine. Over the following decades, the number of projects, researches and investments carried on by universities and companies increased, following the lead of STARPAHC (8).

Telemedicine and orthopedics

Telehealth is a way to provide healthcare services from another location. The most common methods include a live interactive visit with the patient, collecting and analyzing data and imaging, and monitoring patient progress, measuring patient-reported outcomes (3, 9) and the ones provided through data measured by the implemented digital technology (**table I**).

Potential uses of this digital system in healthcare are huge, but what attracts the most is the possibility of using this application in daily clinical practice. Two necessary premises are that telemedicine is feasible as non-inferior with regard to regular healthcare practices and not all patients are eligible for remote treatments.

Table I. Main types of telemedicine.

Three main types of telemedicine	
Interactive medicine	Patients and doctors communicate with each other in real-time
Store and forward	Providers are permitted to share patient health information with physicians elsewhere
Remote patient monitoring	Mobile medical devices are used to collect data which is then used by remote caregivers to monitor patients and health outcomes

The fields of application of telemedicine in orthopedics range from teleconsultation to fracture management, to postoperative follow-up and above all to tele-rehabilitation (3, 10). These medical practices, when provided in the hospital setting, burden the NHS both on the financial side and on the involved resources one (*i.e.*, medical staff), highlighting a huge potential and relevant benefits when the same practices are provided through telemedicine (11).
Published data regarding specifically tele-orthopedics date back to the late 1990's, with the pioneering works of Lamminen *et al.* (2), reporting the experience of independent services. Authors reported their experience with a service of videoconferencing for consultation and communication with good clinical results and patient high satisfaction.
On the same wavelength, there are work of McGill and Caffery. McGill *et al.* (12) remotely followed non-surgical fractures successfully from a technical point of view, in a rural area. Caffery *et al.* (13) explored Australian-based tele-orthopedic services and also reported technology use mainly for fractures and peri-operative consultations. Both studies highlight the importance of telemedicine service in rural and remote areas, due to mobility difficulties and convenience of avoiding long-distance transportation.
In 1997 Lambrecht *et al.* (14) reported an analysis of 410 orthopedic teleconsultations done during a 2-year period by three orthopedic surgeons, they observed no adverse outcomes (**table II**).
Final suggestion of different authors was that telemedicine can be an option where orthopedic physicians are not available for in person treatment.

Table II. Distribution of teleconsultations.

Teleconsultation	% patients
Fractures	43 = 176 p
Ligaments injury, joint swelling, infections	35 = 144 p
Post operative evaluation	18 = 74 p
Evaluation and treatment of dislocations	4 = 16 p

In 1999, Aarnio *et al.* (15) published a prospective study analyzing teleconsultation in orthopedics. In this work, teleconsultations took place by videoconference between two 150 miles distant cities in Finland. This was one of the first studies that reported data about patient satisfaction, where 87% percent of patients considered the remote visit a good or very good method and the rest found it satisfactory.
In 2019, the whole world has been hit by the COVID-19 pandemic which led to a limitation in the movement of people to avoid the widespread of the virus; it is in this period that telemedicine revived great enthusiasm due to the possibility of treating patients directly at home.
Telemedicine for orthopedics has been reported in several scenarios as video-consultations, post-operative follow-up, management of fracture, tele-rehabilitation and also in pediatric cases.

Video consultations

The Orthopedic Video-consultation (OVC) is a special form of digital interaction, where the clinician and the patient carry out the medical examination through dedicated devices. Patients in rural regions may benefit more from video consultations in terms of cost and time. However, even patients in densely populated urban regions with a full-time job could still benefit from a quickly available consultation (16). The possibility of having a better involvement of patients in their treatment thanks to a digital affinity and the corresponding motivation, as well as the possibility of attracting new patients through digital offers, makes the OVC an increasingly used solution by physicians (17). On the other hand, clinicians suspect a lengthening of the telemedicine visit time compared to regular visits and some of them express concerns about the security of the data exchange (18).
In orthopedic trauma, video consultations can be utilized for initial assessment of minor injuries, post-surgical rehabilitation and follow-up, as well as pre-surgical assessment (19). Scientific evidence has shown that especially in orthopedic trauma, there is no difference in terms of satisfaction between in-person and online consultation between patients and doctors and that the efficacy is comparable (20).
One of the questions that spontaneously arises regarding the telemedicine visit is how to carry out a clinical examination of the patient.

Russell's work (21) highlighted how the use of the goniometer web-based practice was statistically comparable to the use of the goniometer in person and Tanaka *et al.* (22) designed protocols and methods to standardize the virtual orthopedic examination for common musculoskeletal conditions.
Obviously, this type of physical exam cannot be compared to the in-person exam, but it can help the practitioner to better address the specific patient condition. and the subsequent healthcare need.

Tele-rehabilitation

Tele-rehabilitation is a way to provide remote rehabilitation services using digital technology, through which is possible to collect and share data between the different medical and non-medical staff involved in the care path, regardless their location and reducing the geographical and access barriers to the care (23, 24).
Tele-rehabilitation and virtual physical therapy are innovative and cost-effective ways to provide the best rehabilitation services to patients without having to move from where they live (25, 26).
Tele-rehabilitation may include assessment, education, monitoring and exercise interventions.
Tele-rehabilitation interventions have been successfully used in the management of chronic diseases. Reduced travel barriers, flexible operating hours and the ability to better integrate skills into daily life are just some of the positive points that emerged from patients' opinion (27).
Tele-rehabilitation interventions decrease travelling costs, are significantly less time consuming and are generally more convenient (28, 29); moreover, tele-rehabilitation allows patients to perform their exercises more frequently without extra face-to-face visits (23, 29).
Moffet *et al.* (30) reported that patients undergoing tele-rehabilitation could benefit from a lightening of the burden of care and greater efficiency leading to a higher perception of quality of life.
Kairy *et al.* (31) stated that tele-rehabilitation in patients with physical disabilities could lead to similar clinical outcomes compared with usual care, with possible positive effects on areas of healthcare utilization (32).

Post-operative follow-up

Telemedicine has been reported useful not only in preoperative and postoperative surgical consultations, but also for intraoperative mentoring with successful outcomes for patients (33, 34).
The use of mHealth in orthopedic surgery has been shown to be very important in increasing patient involvement in the therapeutic process through better control and management of postoperative pain (35).
Survey systems to collect patient-reported pain levels, opioid consumption, and adverse effects in the acute postoperative period after total knee arthroplasty (TKA), total hip arthroplasty (THA), and surgery of the lumbar spine, according to many studies, are considered important in the post-operative management of the patient (36-39).
Acute and chronic pain is influenced by psychological factors that could result in interference with patients' activities of daily living and decreased quality of life. Communication via smartphone or other device, therefore not in person, has proven useful and effective in reducing the use of opioids and in the treatment of various psychological conditions and cognitive problems (38, 40).
In addition, with regards to post-operative pain management, telemedicine has also proved to be of great importance in all those patients who had been prescribed anticoagulant therapy (ASA) for the prophylaxis of venous thrombosis. Through the use of a real telephone alarm clinicians have found an improvement in therapeutic adherence (41).

Cost-effectiveness of telemedicine in orthopedic

Telemedicine consultations using real-time videoconferencing has the potential of reducing health care costs, indeed in the recent years various studies have faced the cost effectiveness of telemedicine (42-45).
Buvik *et al.* (42) reported a reduction of costs using videoconferencing for orthopedic consultations in the remote clinic compared to standard outpatient consultations at the specialist hospital, if the total number of patient consultations exceeds 151 per year. If costs were calculated from a health sector perspective, rather than a societal perspective, the number of consultations needed to break even was 183.
Tousignant *et al.* (46) documented costs for in-home tele-treatment *versus* conventional home-visit rehabilitation following TKA based on an RCT, demonstrating the cost savings of tele-treatment compared to home visits for patients post-TKA.
Patients revealed particularly high satisfaction with telemedicine for reasons of convenience, reduced appointment delays, travelling times, travel costs and time off work, findings which support existing literature on high patient satisfaction with telemedicine (47).
EBM (Evidence Based Medicine) suggests that once patients were exposed to telehealth, a majority preferred further follow-up using digital technology (48). High patient satisfaction is associated with an increased patient compliance and consequently with a reduction in missed appointments. Missed appointments cost the UK NHS £1 billion a year (49); patient compliance consequently translates into cost savings for the healthcare system.

AI in orthopedics

Computer-navigation, robot-assistance and three-dimensional digital planning have become commonplace in many parts of the world. With advances in computer processing power and the development of new softwares, orthopedic medicine and surgery have begun to delve into artificial intelligence (AI) systems (50).

There are conceivably diagnostic, decision-making and technique execution, and administrative considerations, automating the interpretation of radiologic imaging.

AI applications have already been employed to either improve the accuracy of or reduce the time associated with critical diagnostic steps. This may involve recognition and classification of pathology, or the correct determination of in situ implant types/models (51).

Large volumes of patient data, ever-increasing patient expectations of positive post-surgical outcomes, and a profession-driven push to improve the quality and precision of care we offer have opened many avenues for AI use. Orthopedic applications include image recognition (diagnostics/implant identification) (52), risk prediction, cost-outcome determinations, clinical decision making seem popular early targets of AI technologies. Applications in primary TKA (53), primary total hip arthroplasty (THA) and resurfacing (54), and primary total shoulder arthroplasty (TSA) (55, 56) have all been reported with positive value.

Zhao *et al.* (57) demonstrated that with AI, classification of osteoarthritis from plain radiographs was as accurate as that of trained arthroplasty surgeons, but faster.

As medicine and surgery push onward towards a seemingly inevitable uptake of technology-assisted data management (including potentially AI applications), a unique opportunity for a more universal commitment to "standardization" of prospective patient data capture and storage arises.

CONCLUSIONS

The application of telemedicine in orthopedics has expanded the fields of application with positive outcomes in terms of effectiveness, efficiency, and patients' satisfaction. It can be used in different scenarios such as postoperative follow-up of selected cases, video-consultations, and even orthopedic trauma. Remote care had dramatically increase in 2020 due to COVID-19 pandemic. This trend will be confirmed, and the adoption of telemedicine practices will continue to expand because due to the necessary digital evolution that is characterizing the medical practice. Over the last few years, different tools and technologies to provide rehabilitative care at a distance have been developed, studied, and validated. However, the implemented technologies and the validated practices could not be used for all the pathologies and further investments in research are necessary to implement effective telemedicine protocols for as many pathologies/healthcare needs as possible.

Data security and privacy are two important aspects for the successful use of mHealth systems, both for patients and professionals. Special attention must be paid to sharing sensitive patients' data, that must always be done in compliance with European regulations or current privacy regulations.

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DATA AVAILABILITY

N/A.

CONTRIBUTIONS

FO, AB: writing – original draft, writing – review & editing, study selection, data collection and extraction, risk of study bias assessment. FO: methods. GS: writing – original draft, study selection, data collection. MC: writing – original draft, writing – review & editing. GO: writing – original draft, writing – review & editing. NM: writing – original draft, writing – review & editing, final approval. All authors: final approval.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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