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DEPARTMENT OF CLINICAL MEDICINE

Applications of Telemedicine in Dentistry

Review of Literature

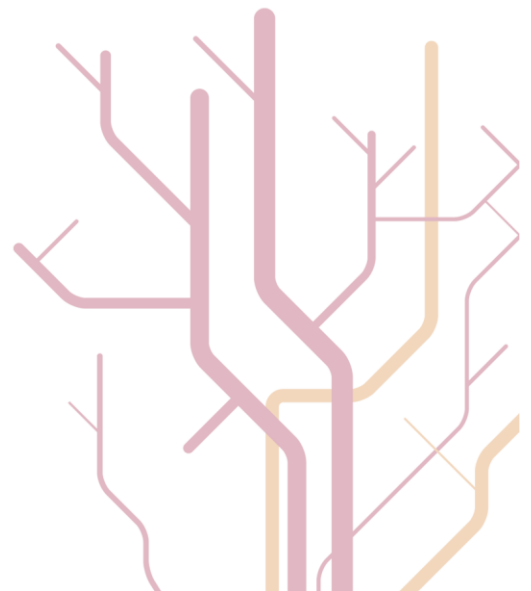
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ABSTRACT

The aim of this study was to review the different papers and articles that discuss applications of telemedicine in the dental field. This study is qualitative narrative review of literature. Research of teledentistry literature was conducted in order to identify the relevant articles. The research focused on the electronic database of US National library of medicine .National institute of health (Pubmed.gov) and Journal of telemedicine and telecare. Specific keywords that were used in the research: “Teledentistry”, “Telemedicine and dentistry” and “Dental videoconferencing” and others corresponding words. 294 Papers have been identified. After applying the inclusion and exclusion criteria 53 articles have been found relevant to be selected for our study which represents small percent compared to the literature discussing telemedicine applications in general.

The selected articles were categorized according to area of intervention in the different dental specialties in addition to category includes articles that discuss the use of telemedicine in general without focusing on specific dental specialty and another category that includes applying telemedicine in the field of dental education.

Analysis and study of these articles revealed that more number of articles focused on incorporating teledentistry into specific dental specialties and aspects while incorporating teledentistry within some other dental specialties had been relatively neglected. Articles focused more on applying teledentistry in oral surgery and orthodontics and oral medicine as well using teledentistry for the purpose of dental education while specialties like prosthodontics, restorative and pediatric dentistry have been relatively neglected with fewer number of articles discussing using teledentistry in these fields. More researches are required within these fields.

The majority of articles included in the review discussed applying teleconsultation systems that allow communication between general dental practitioners and specialists. This can be attributed to the current availability and relatively low costs of the basic infrastructure required for such teleconsultation systems. However, more researches are required to study using teledentistry in the operative or surgical phase in dentistry. The shortage of this kind of researches can be attributed to the complicated, advanced and expensive technology required for such teledentistry systems for example the robotic surgery.

Despite this small number of articles discussing using teledentistry in the different dental fields, results of the majority of the articles relevant to the review achieved positive outcome after

implementation of the teledentistry systems. These positive outcomes in addition to the continuous advancement of information technology makes us expect increasing in the number of studies that investigate incorporating teledentistry in dentistry in the future and the expand of these applications into more dental specialties as well as the different aspects of dentistry including the operative and surgical phase in addition to the consultation and diagnostic aspects.

INTRODUCTION

Background

According to Norris C. Telemedicine is defined as the Utilize of information and telecommunications technology to transfer medical information for diagnosis, therapy, and education (1). Moreover, Lehoux et al. defined telemedicine as the use of information technology to support delivery of health care from a distance (2). There are few definitions of telemedicine according to the different interests of medical doctors, patients and technologist. For instance, telemedicine is usually seen by technologist as a part of the medical informatics field. They consider telemedicine discipline within the informatics.

Telemedicine has been applied in different medical fields. Many of the applications of telemedicine have been studied in various clinical trials and implemented in daily clinical practice. Such applications include telereadiology, telepsychiatry, telesurgery, telecytopathology, teledermatology and teledentistry as well as other telemedicine applications in different medical specialties.

In our study we will focus on telemedicine applications in the dental field known as teledentistry. Teledentistry has been developing since 1994 and it is defined as a mean aiming to achieve better communication between dental professionals over long distances (3). It allows collaboration by multiple practitioners in order to reach the accurate diagnosis and set the adequate treatment plan regarding individual patient. Teledentistry can help those living rural areas suffering from shortage in the number of dental specialist like oral medicine specialists, orthodontists, periodontists or oral surgeons. People living in such rural areas will be able to have access to those specialists through their local general dental practitioner. The dental practice nowadays depends more on the digital media.

Implementation of electronic medical records (EMR) in dental practices as well as the use of digital radiography and digital clinical photography using intra oral cameras facilitate the application of different teledentistry systems and increase the chance of their successful implementation in daily clinical practices. The general dental practitioners can share the patient information, clinical examinations findings, radiographs, clinical photographs, laboratory results and the general practitioners notes and differential diagnosis regarding the case.

Four types of telemedicine can be identified (1);

1. Teleconsultation

Studies have shown that 30% of telemedicine networks belong to the teleconsultation type. Many of telemedicine applications in the dental field are based on the teleconsultation concept. Two techniques can be used to perform the teleconsultation; either the asynchronous consultation or the synchronous one (4). Asynchronous consultation is based on the “store and forward” concept. For example the general practitioner record and stored all the data about a certain patient and all the clinical findings and results regarding this patients and then send all these stored data to the specialist seeking for the medical consultation from him to support the medical decision about the patient case. One of the main advantage of applying the store and forward concept is that the two involved partners do not need to be present at the same time for the transfer of data.

The other technique used in teleconsultation is the synchronous one. Synchronous teleconsultation occurs in real time and it requires the presence of the two involved partners at the time of data transfer. It varies from telephone consultation to using Videoconferencing which allows direct visualization and dialogue with the patient. It is usually performed by the health care professional to seek for decision support for diagnosis and treatment of a certain patient. The requirements to achieve the maximum benefits from teleconsultation process have been identified by Tachakra and Haig (5). According to them the requirements for successful teleconsultation process are:

- Agree on the purpose of the teleconsultation
- Establish the process and content of the teleconsultation
- Ensure that the practitioners are trained to use the equipment in proper way
- Formalism the delegation of clinical responsibilities
- Decide on documentation as the whole procedure and outcomes should be documented by the health care professionals and incorporated in the patient medical record.

2. Tele-education.

Several types of tele-education can be distinguished according to the recipient and the type of transmission (1)

- Clinical education from the teleconsultation
- Clinical education via internet

- Academic study via the internet
- Public education via the internet

Moreover; formal online education can be divided into two main categories: (6)

- Web-based self-instruction. This educational system contains information that has been developed and stored before the user accesses the program
- Interactive videoconferencing. This educational system includes both a live interactive videoconference (with at least one camera set up where the patient's information is transmitted; however, cameras at both locations are ideal) and supportive information (such as patient's medical history, radiographs) that can be sent before or at the same time) as the videoconference

3. Telemonitoring

Telemonitoring is the use of a telecommunications system to gather routine or repeated data about patient's condition. This process can be performed manually or automatically; In case of manual gathering of the data, the patient records the data and transmits them by telephone, facsimile or a computer/modem system. Alternatively, the acquisition may be entirely automated so that continuous data can be submitted either in real time or in store-and-forward mode.

4. Telesurgery

It is practiced in two ways; Telementoring and robotic surgery. Telemonitoring application in surgery includes the assistance given by specialists to surgeons carrying out a surgical procedure at a remote location. The assistance is offered via a video and audio connection that can extend elsewhere in the building or over a satellite link to another country. This form of telesurgery is clearly linked to tele-education

The other approach is tele-presence surgery, which guides robotic arms to carry out remote surgical procedures.

Definitions of Teledentistry

Teledentistry is a combination of telecommunications and dentistry, involving the exchange of clinical information and images over remote distances for dental consultation and treatment planning. The term "Teledentistry" was used for the first time when Cook defined it as "the

practice of using video-conferencing technologies to diagnose and provide advice about treatment over a distance” (7)

History

Teledentistry has been developing in Western Europe and USA since the mid 90s as a mean to allow dental professionals to communicate with one another over long distances however the initial concept of teledentistry developed as part of the blueprint for dental informatics which is a new domain combining computer and information science, engineering and technology in all areas of oral health, which was drafted at a 1989 conference funded by the Westinghouse Electronics Systems Group in Baltimore. Three groups of workshop participants addressed issues relating to dental informatics and telecommunications used in dentistry. Only the first of these is relevant to teledentistry, and its focus was a discussion of how to apply dental informatics in dental practice to directly affect the delivery of oral health care (8).

It began in USA in 1994 as a military project to improve patient care, provide continuing dental education and establish dentist–laboratory communications (3). The project is known as “Total Dental Access (TDA). The goals of the project was to increase patient access to quality dental care and to establish a cost effective telemedicine system.

Total Dental Access project focuses on three areas of dentistry:

- Patient care: implementation of teledentistry is a potential of savings in cost and travel time required by the patient. Referral to specialists, consultations and laboratory communications are some of the clinical areas where teledentistry could improve the patient care.
- Continuing Dental Education: Through the use of video teleconferencing equipment, the lectures could be broadcasted to any clinic where continuing dental education is difficult to obtain.
- Dentist-laboratory communications: Occasionally, cases submitted to the dental laboratories have complications or esthetic nuances that require direct contact between the dentist and the laboratory technician. In these cases, the ability to send color images of the patient's teeth and then to talk about the images can help to prevent making improperly constructed appliances, and help in saving time and money.

This military project concluded that teledentistry decreased overall cost, was expandable to remote and rural areas, and offered more complete information for data analysis.

In Norway, the Norwegian Centre for Integrated Care and Telemedicine (NST) has been involved in two projects implementing teledentistry system. First, Sv@lTooth (9) which is a teleodontological pilot web-based service between Svalbard and Bergen in Norway. In October 2001, a plan was initiated to establish a web-based communication between the dentist at Longyearbyen Hospital on Svalbard and orthodontist in Bergen in Western Norway. Results indicated that the web site may improve the communication between the local dentist and the orthodontist and make it easier for the latter to stay updated on patients under therapy.

The other project is the OrtoPol@r (10) which is University-far distance education system in orthodontics at the Dental Competence Centre in North Norway. The project based on the idea that a decentralized specialist education will contribute to geographical distribution of specialists. Using telemedical solution, students at Dental Competence Centre in North Norway follow the same teaching as corresponding students at the Faculty of Dentistry, University of Oslo. Telemedicine offers a broader co-operation and exchange of skilled competence. Different telemedical solution has been used in this project. A video conference room was installed at the faculties in Oslo and Bergen as well as the Dental Competence Centre in North Norway. Moreover, investment in digital x-ray equipment and cameras are also made.

Forms of Teledentistry

Teledentistry can take two forms:

(1) Real-time consultation

(2) Store and forward.

Real-time consultation involves a videoconference in which dental professionals and their patients, at different locations, may see, hear, and communicate with one another actually using advanced telecommunication technology and ultra-high-bandwidth network Connections.

On the other hand, store and forward form of teledentistry involves the exchange of clinical information and static images collected and stored in the telecommunication equipment. In store and forward, the dental practitioner collects all the required clinical information and digital intraoral and extra oral images and radiographs (or scanned, originally no digital images) and forwards them for consultation and treatment planning via established networks and/or the Internet. This allows collaboration between general practitioners and specialist regarding a patient and the necessary treatment for this patient. It involves the local dentist digitizing and

electronically transmitting clinical photographs, and X-rays to the specialist and thus enables the specialist to make a diagnosis and recommend treatment options or referral (11).

The need for teledentistry

First of all we need to discuss why there is a need to apply telemedicine applications within the different dental fields and if investing time and money in research regarding this field as well as the implementation of such applications can be beneficial in providing better dental care for the patients.

Few factors can be discussed in an attempt to answer such question about the need of teledentistry

- Providing specialized dental care for people living in Rural areas
- Communication between dental clinics and dental labs
- Providing dental care for medically compromised patients
- Hospital consultation
- Dental education

Providing specialize dental care for people living in rural areas

Implementation of teledentistry system in developing country can help to provide specialized dental care especially for those living in rural communities as most of dental specialists are found in urban areas (12). These rural communities usually suffer from lack of oral healthcare providers as well as the inaccessibility to quality dental care. Many rural communities lack the clinical settings and finances that are required to attract specialized dental providers. Patients living in these rural are quite often referred to dental care providers in more urban regions so they must travel to these areas which is usually expensive and time consuming. Teledentistry can play a major role in closing this distance gap by allowing oral healthcare providers in the rural areas to seek advice from specialists in the urban settings. This can be performed without the patient need to physically enter the specialty practice. An appropriate treatment plan can be devised prior to a direct patient–specialist visit. In conclusion, Teledentistry can increase the accessibility of the specialists to the rural and underserved communities for their dental needs, besides decreasing the time and the cost which are associated with the specialty consultations (13).

Dealing with the shortage of dentists

Teledentistry can play an important role to deal with the projected problem of dentists' shortage in the following years. In this way teledentistry will be important not only for rural areas but also for the urban and suburban populations (14).

Communication between dental hygienists and dentists as well as general dentists and dental specialists

Teledentistry can play important role in facilitating the communication between dental hygienists and dentists. For instance; when a dental hygienist has a patient with a painful periapical abscess, the dental hygienist could send a radiograph of the area, an intraoral photograph, all charting and health history information, and then consult with the dentist regarding the adequate diagnosis of the case. If the dental diagnosis determines that the patient needs treatment in an endodontic practice, the dentist could write a prescription for an antibiotic and pain reliever. The dental hygienist can then share the information gathered with the endodontist. These teledentistry consultations are beneficial for the patient for several reasons. The patient only has to travel the distance for a visit to the specialist, and not to the general practitioner as well. The patient will be able to receive prescriptions for medication to prepare the area for treatment, as well as relieving his discomfort (15).

Moreover teledentistry enables general dentists to send multimedia patient records including images, videos, texts and sounds to dental specialists which give the specialist the chance for diagnosis and developing a proper treatment plan without the need to see the patient in person. Such communications can play a major role in improving the dental care provided for the patient and improving the health care delivery system as a whole.

Dental clinic and dental lab communication

While working with a dental laboratory, a dentist may need to provide additional information to the laboratory. Teledentistry would allow the dentist to provide the laboratory technicians with colour images of the patient's teeth. Detailed instructions can be given as well showing the exact measurement specifications of the patient. This would decrease the chance of an appliance being made incorrectly for the patient. Discussion between the dentist and dental technician about the images can help to avoid making improperly constructed appliances and thus saving time and money.

Providing dental care for medically compromised patients

Teledentistry can help medically compromised patients to get better dental care via such communication between general dentists and dental specialist as well as between dentists and the medical doctors of the patients regarding their specific medical conditions. The technology would allow easy consultation between multiple medical disciplines as well as the accuracy of the provided information of the patient medical condition. This can also help in case of hospitalized patients who need adequate dental care.

Teledentistry literature reviews

In 2010, a review of literature was conducted in India discussing the unexplored potential of teledentistry presenting different articles discussing using teledentistry in different dental specialties (16). The study focused on the potential of teledentistry to address the problems related to access, cost, efficiency, and the quality of dental care. The study also discussed the legal issues related to using teledentistry as well as the benefits of applying teledentistry.

In 2011, another review of literature study was conducted in Serbia (17). Beside covering articles discussing using of teledentistry in different dental specialties, it also focused on the concept of computerized dentistry as well as the internet as the basis of teledentistry.

Moreover in 2011, a review of literature study was conducted in India that reviewed the origin, rationale, scope, basis, and requirements for teledentistry, along with the current evidence that exists in the literature (18). In addition, the article also reviewed the ethical and legal issues related to teledentistry and its potential in the future

In 2012, a review of literature study was conducted in UK. In this study diffusion of innovation theory was used to develop a better understanding of the challenges facing teledental projects, and outline the factors that impact upon the adoption and implementation of these projects, with a focus on orthodontics (19).

In 2013 during conducting our study, a systemic review on teledentistry literature was conducted in Australia and published in March. Results of this review indicated that although teledentistry is an area of expansion, there are still some barriers to its increased use (20).

QUESTIONS OF RESEARCH

The aim of this study was to review the different papers and articles that discuss the applications of telemedicine in the dental field in an attempt to clarify the different methods of implementation of these applications and the outcome of applying them on improving access to oral health care as well as the delivery of the dental treatment and lowering the cost of the dental treatment. The study attempted to investigate the required infrastructure for the implementation of successful teledentistry applications.

The study also aimed to discuss the future prospectives of teledentistry application based on what has been achieved in the present time. This review covered studies that discuss the implementation of telemedicine applications in the different dental fields including oral and maxillofacial surgery, oral medicine and diagnosis, prosthodontics, orthodontics, pediatrics and restorative dentistry as well as the application of telemedicine in dental education. Moreover the review aimed to investigate distribution of articles on different dental specialties to clarify if literature focused more on specific dental specialties compared to others and what could be the reasons behind that.

METHODS

This study is a qualitative narrative review of literature rather than systematic one. Research of teledentistry literature was conducted in order to identify the relevant articles. The research focused on the electronic database of The US National library of medicine .National institute of health (Pubmed.gov) and The Journal of Telemedicine and Telecare. Specific keywords that were used in the search: “Teledentistry”, “Telemedicine and dentistry”, “Dental videoconferencing”, “Telemedicine and Orthodontics”, “Telemedicine and Oral Surgery”, “Telemedicine and Oral medicine” Telemedicine and Periodontics”, “Telemedicine and Prosthodontics”, “Telemedicine and Restorative Dentistry”, “Telemedicine and Pediatric Dentistry”.

The next step was refining of the selected articles .Each article was assessed against the inclusion criteria of our study. These inclusion criteria include the following:

- Studies focus exclusively on telemedicine applications in the dental field not any other medical field
- Studies that compared teledentistry to standard health care methods
- Studies that were published from January 2000 to March 2013
- Studies that are written in English or with an English abstract

One the other hand exclusion criteria include the following:

- Studies that have been written in languages other than English
- Studies that have been published before January 2000
- Studies with no abstracts when retrieved from the electronic database
- Reviews of literatures studies

Browsing of the articles titles and abstract was performed to determine the relevant articles for the review of literature. The following step was comprehensive reading and summarizing of the selected articles. Analysis of each of these articles was performed. Information about the year of publication and country where the studies were conducted was obtained and presented in graphical charts.

Those articles were categorized according to area of intervention i.e. dental specialty for example: orthodontics , prosthodontics ,Restorative dentistry ,oral surgery, oral medicine , pedodontics , periodontic in additional to category includes studies that discuss application of telemedicine in dentistry in general without focusing on specific dental specialty and another for

articles discussing using telemedicine for the purpose of dental education. Due to the verities of topics covered by the articles in the category that includes the articles discussing teledentistry in general includes it will be divided into 4 sub categories.

Theoretical Framework

Information infrastructure theory was chosen as theoretical framework to be applied on the articles that have been found relevant to our study and findings of the review of literature.

Information Infrastructure

Good understanding of the concept of information infrastructure and good analysis of its core components can be the key factor of successful implementation of information and communication technology system (ICT) within a certain organization. Information infrastructure has a dual and paradoxical nature (21). According to star and Ruhleder “infrastructure is both engine and barrier for change; both customizable and rigid; both inside and outside organizational practices. It is product and process”(21).

The concept of Information Infrastructure may be seen as a combination, or merge, of information and infrastructure technologies. According to Hanseth and Monteiro “Information Infrastructure can be seen as a step in the development of information technologies as well as a step in the development and infrastructure technologies.” (22) Information infrastructures share a number of aspects with other kinds of information technologies while having some unique aspects making them different”. Furthermore, Hanseth and Moteiro explain these different key aspects.

- The first aspect is the enabling function which means that the infrastructure is designed to support a wide range of activities rather than a single one. Thus the technology opens up field of new activities not just improving existing one.
- The second aspect is that infrastructure being shared by a larger community or in the EPR system case a group of users. In this way infrastructure should be seen as irreducible, they cannot be split into separate parts being used by different groups independently. However, an infrastructure decomposed into separate units of analytical or design purposes.
- The third aspect is infrastructures being open in a sense that there are no limits of number of users. A clear example of such aspect within the health care system is the hospital exchanging information with other medical institutions maybe even in different countries.

It also exchanges information with insurance companies and pharmaceutical companies as well as the different companies from which the hospital orders goods.

- The fourth aspect of infrastructure is the socio-technical one. Infrastructure is more than pure technology. Information infrastructure encompasses technological components, human, organizations and institutions. Ignoring this aspect usually leads to failure of the implementation of ICT system or at least failure to achieve the required goals and maximum benefits. Actor Network Theory (ANT) can give us a clear explanation of this aspect of information infrastructure (23). Actor Network Theory offers an illuminating vocabulary to describe information infrastructure. It provides a language to describe how, where and to which extent technology influences human behavior. It is the act linked together with all of its influencing factors (which are linked), producing a network. An actor-network consists of and links together both technical and non-technical elements.
- The fifth aspect is that Infrastructures are connected and interrelated, constituting ecologies of networks. One of the main features of information infrastructure is the heterogeneity of its different components creating a seamless information infrastructure. Such heterogeneity is caused when a part of an information infrastructure is replaced by another one. During the transition period the infrastructure will consist of the two interconnected networks. Another form which leads to heterogeneity is when a large infrastructure will be developed by interconnecting two existing different ones. Finally heterogeneity can be caused when larger components or infrastructures are built based on existing independent smaller components. When these components are brought together into a larger unit, they become interdependent.

There are different definitions of infrastructure and authors have discussed infrastructure features in different ways. According to McGarty (24) infrastructure resources is characterized by being:

- Shareable. The resource must be able to be used by any set of users in any context consistent with its overall goals.
- Common. The resource must present a common and consistent interface to all users.
- Enabling. The resource must provide the basis for any user or set of users to create, develop, and implement any applications, utilities, or services consistent with its goals.
- Physical embodiment of architecture. The infrastructure is the physical expression of an underlying architecture. It expresses a world-view which must be balanced with all the other elements of the infrastructure.
- Enduring. The resource must be capable of lasting for an extensive period of time.

- Scale. The resource can add any number of users or uses and can by its very nature expand in a structured manner in order to ensure consistent levels of service.
- Economically sustainable. The resource must have economic viability. It must meet the needs of both customers and providers of information products.

Star and Ruhleder (25) give another definition for information infrastructure, putting more emphasis on the social relations constituting infrastructures and explaining the different dimension of infrastructure. These dimensions are:

- Embeddedness. Infrastructure is "sunk" into, inside of, other structures, social arrangements and technologies;
- Transparency. Infrastructure is transparent in use, this means that there is no need for infrastructure to be reinvented each time or assembled for each task, but it should be capable to invisibly supports these tasks;
- Reach or scope. This may be either spatial or temporal - infrastructure has reach beyond a single event or one-site practice;
- Learned as part of membership.
- Links with conventions of practice. Infrastructure both shapes and is shaped by the conventions of a community of practice,
- Embodiment of standards.
- Built on an installed base. Infrastructure inherits strengths and limitations from that base.
- Becomes visible upon breakdown. The normally invisible quality of working infrastructure becomes visible when it breaks

RESULTS

After searching for teledentistry literature in the previously mentioned electronic data bases using the specific keywords mentioned in the method chapter, 294 Papers have been identified. After applying the inclusion and exclusion criteria as well as excluding the duplicated, 53 articles have been found relevant to be selected for our study.

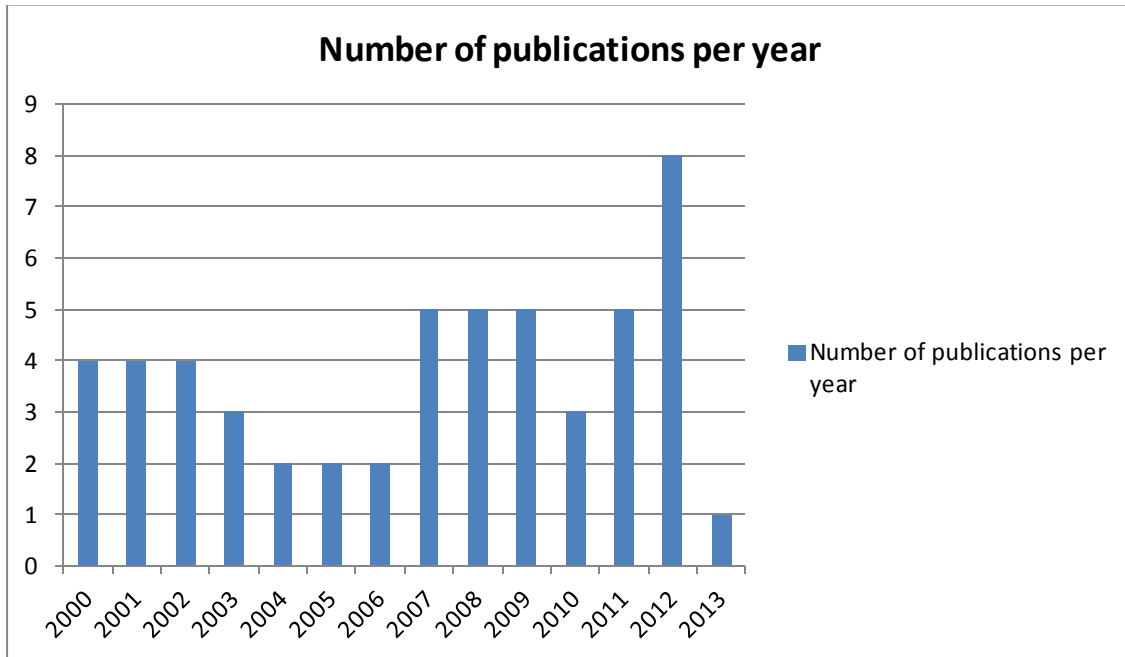
Table.1:

➤ Countries where studies were conducted

Countries	Number of Studies
USA	18
UK	15
Japan	3
Germany	2
Sweden	2
Spain	2
Finland	2
India	2
South Korea	1
Austria	1
Switzerland	1
Ireland	1
Brazil	1
Portugal	1
Italy	1

Table.2:

➤ The number of articles that have been found relevant for our study per year



The selected articles were categorized according to area of intervention in the different dental specialties in addition to a category includes articles that discuss the use of telemedicine in general without focusing on dental specialty and another category that includes articles that discuss applying telemedicine in the field of dental education.

Fig.1: Categorization of the articles selected for the review

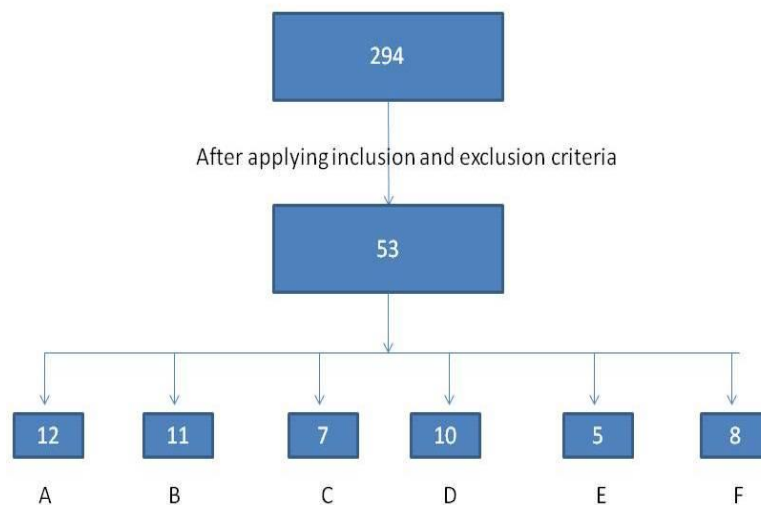


Table.3 Categories of the articles selected for the review

- A. Articles that discuss teledentistry in general without focusing on a specific dental specialty n=12
- B. Articles discussing applying telemedicine in dental education field n=11
- C. Articles discussing applying telemedicine in orthodontics n=7
- D. Articles discussing applying telemedicine in oral surgery n=10
- E. Articles discussing applying telemedicine in oral medicine and periodontics n=5
- F. Articles discussing applying telemedicine in prosthodontics, restorative and pediatric dentistry n=8

In the next part of our study we will summarize and discuss the articles of each category in an attempt answer the questions of research

Articles discussing teledentistry in general (n=12)

This category includes articles that discuss teledentistry in general without focusing on specific dental specialty or the application of telemedicine in dental education. Among the articles that have been found relevant for our study twelve lie in this category.

The twelve articles in this category can be classified into four subcategories:

- Articles discussing using teledentistry to provide dental treatment for rural and underserved areas
- Articles discussing examples of telemedicine applications in dentistry and the role of technology in teledentistry in general
- Articles discussing self and oral home care
- Articles discussing the economic outcome of applying telemedicine in dentistry and the legal challenges of the implementation of such applications

Articles discussing using teledentistry to provide dental treatment for rural and underserved areas

As has been discussed previously, the implementation of teledentistry can help to provide specialized dental care for those living in rural communities in geographically separated locations as most of dental specialists are found in urban areas. Few articles discussed the impact of applying teledentistry in improving the access of dental care for underserved populations and

communities and in turn improving the oral health of such communities. The inaccessibility of such communities or individuals to the adequate dental treatment could be due to geographic or economic factors and in some cases due to ethnographic reasons.

Among the articles that have been found relevant for our study four have been discussing this topic. Two of these studies have been conducted by James Friction and Hong Chen from the School of Dentistry at University Minnesota. In 2007 they published an article discussing pilot project presenting the experience of applying real-time videoconferencing technology at the University Of Minnesota, School of Dentistry (UMNSOD) for the purpose of increasing access to dental specialty care in rural Minnesota (26). The goal of the project was to create a teledentistry network linking University of Minnesota School of Dentistry specialists to dental practitioners and patients in sites in remote rural areas where there are problems regarding the accessibility to dental care.

The project focused on specific dental specialties including Temporomandibular Disorders, Orofacial Pain and Oral Medicine. The reason the project focused on these conditions that it has been noticed that such conditions are very common in the general population and associated with potentially high morbidity rate as well. On the other hand, there is shortage of dental specialists that are well trained and capable of managing such conditions. Store and forward and live videoconferencing were used for teleconsultation between specialist at the dental school and general dental practitioners and patients at the chosen sites in the remote rural areas. The remote sites were provided with portable videoconferencing unit, Data Solution Box, and an accessory intra-oral camera.

According to the authors, the results of evaluation of the project showed high satisfaction and acceptance to the teledentistry consults. In over 90% of the visits, the specialists were satisfied with the teleconsults. In about 94% of the visits, specialists were as confident about providing adequate diagnosis and treatment planning as in a face-to-face visit. Moreover, the patients reported high satisfaction with teledentistry program as well. The main advantage of applying such system for the patient was reducing the travel time and the time being off. The authors concludes that the project had received high satisfaction evaluation from both patients and dental specialists. However more evaluation is required of the cost, effectiveness, and outcomes of the project

In 2009 James Friction and Hong Chen publish another article regarding the same project in an attempt to evaluate in more details the outcome of applying the project and the specialists as well

as the patients' satisfaction of the teledentistry system compared to the conventional face to face dental visit (27). The study discussed using teledentistry to improve access to dental care for the underserved patients. Underserved patients are those who have problems to get access to adequate oral health care. This may be due to geographical factors like the remoteness of people living in rural areas .Also the adverse seasonal weather bad road condition as well as poor or lack of transportation can play a negative role. Another important factor is the economical factor. Among the group of underserved patient are those suffering from poverty and lack of health insurance. In this study the authors discussed how applying teledentistry can help those underserved patients to get better accessibility to dental care.

In 2011 a study was conducted in India discussing using teledentistry to provide access to specialists for rural Indians aiming to suggest a suitable approach to the policy makers, through which these rural Indians can access specialty dental care (12). There are many barriers for the rural Indians to access specialty dental care, such as geographic remoteness, poor or no public transportation, and poverty, leading to a compromise on quality dental care, resulting in complications. Teledentistry could be one of the possible option overcome such complications. According to author "India, with its diverse landmass, huge rural population and existing health care delivery mechanism clubbed with advances in telecommunications technology, could be an ideal setting for teledentistry". Moreover, he suggested that dental colleges can act as hub sites for teledentistry consultation as highly experienced specialists in different dental fields are usually working in such college

In 2012 another study was conducted in USA by Paul Glassman et al. discussing the use of telehealth technologies to improve oral Health for vulnerable and underserved Populations focusing on the state of California (28). The article mentioned California HealthCare Foundation report in 2008 "Telemedicine in California: Progress, Challenges, and Opportunities" which reviewed the history and use of telemedicine both nationally in USA and in state of California. Then it focused on teledentistry and the history of applying telemedicine in the dental field in USA. The article discussed the virtual dental home project, which was directed by the Pacific Center for Special Care at the University of the Pacific Arthur A. Dugoni School of Dentistry.

Moreover the study discussed another example of teledentistry application that aims to facilitate oral health care which is the delivery system from Apple Tree Dental (Apple Tree) in Minnesota. The authors describe how the Apple tree dental project is working linking dental hygienists with dentists. According to the author it has be demonstrated the ability for a dentist at a distant dental clinic to access accurately the permanent teeth of high risk children for sealant placement without

the need for a face-to-face examination. To achieve that live videoconferencing has been used as well as digital radiographs and high-resolution intraoral videos and images.

The article discussed in details the barriers to adoption and spread of telehealth. The authors enumerate few barriers which include:

- The uncertainty of payment for services,
- Difficulties in developing and sustaining provider networks
- The challenge of integrating technology among providers,
- Lack of training resources

Finally the article presented a new law that becomes effective on January 2012 in California aiming known as “Telehealth Advancement Act of 2011”. This law updates the definition of telehealth to reflect the different and broad range of telehealth services in use today. Also this law and allows all licensed health professionals in California to engage in telehealth.

The article cover few more aspects and it can also lies in the subcategory that includes articles discussing role of technology in general in teledentistry as well as the subcategory of articles discussing the legal challenge of the providing telehealth services.

Articles discussing examples of telemedicine applications in dentistry and role of technology in teledentistry in general

Among the articles that have been found relevant for our study three lie in this subcategory. Paul Glassman et al. published another article focusing mainly on virtual dental home project that was mentioned previously(29). The project was described by the article as “innovative new model for delivering dental care which is applicable for a wide variety of population groups, especially those who are currently inadequately served in traditional dental settings”.

The services provided in the project include diagnostic, preventive, and early intervention restorative care. The idea of the project based on registered dental hygienists and registered dental assistants placing interim therapeutic restorations according to the instructions given to them by the dentists. The dentists involved in the project review electronic records and make diagnostic and treatment decisions while the allied dental professionals including the dental hygienists and dental assistants collect records and provide preventive and early intervention services in community settings under the supervision of dentists. The project is operating in nine sites in California.

Regarding the technological aspect of the project, virtual dental home model of care uses a cloud-based electronic health record (EHR) system called Denticon (30) which allows records to be collected in one location and reviewed in a geographically separate location and thus allow communication and sharing records between dentist dental hygienists and dental assistants on one side and dentists on the other side.

Finally, the authors summarized their recommendations to facilitate realization of the full benefits of the virtual dental home model. The most significant recommendation includes

- Expanding the project by applying it to additional populations and sites focusing on the underserved groups and communities that face difficulties to gain access to proper dental care
- Educating caregivers and administrators of agencies and institutions that provide education, general health and social services about health, and social services about the importance of oral health and the benefits of applying the virtual dental home model. Moreover, encouraging them to participate in developing the model and develop a vision for how the model can help them in their own work as well as how it can help the patient in the selected sites where the model is applied
- Support and encourage the adoption and spread of Electronic patient records (EPR) in dental practices. EPR is the basis of this model as well as of any successful telemedicine application in the dental field
- Promoting the virtual dental home model in an attempt to advocate government health programs like state Medicaid to provide funding for such pilots systems of care as well providing support for studies about the health outcomes of these systems

The second articles that lies in this subcategory was a study conducted in South Korea in 2009 to test the suitability of three image devices in emergency dental situations for telemedicine. These three devices were special-purpose oral camera, a digital single lens reflex (DSLR) camera, and the built-in camera of a mobile phone (31).

Dental accidents are common and dentists are not always available where required. In such cases the initial assessment of dentoalveolar trauma is very important to avoid or reduce further post-traumatic complications such as root resorption, pulp necrosis and tooth loss (32). This makes providing adequate communication methods between the patient and the dentist quite useful in the diagnosis process and making medical decision regarding the case of the dental emergency or providing dental first aid to the patient.

According to the authors, the requirements of image in dental emergency situations are the quality of the image, connectivity, and the user convenience including transmission time. The image quality, connectivity and a simple capture method are main factors of the successful teledentistry factors in the success of a teledentistry service. The three devices that were tested in the study were evaluated and compared to each other according to these three requirements.

In this study 20 subjects volunteered to take part. Four images were taken with each of the three devices. This includes images of the frontal and occlusal view of the maxillary anterior teeth that were taken the light of a dental unit chair. Two dental experts rated the images as ‘success’ or ‘failure’ for emergency assessment on the basis of information observed from the images regarding the status of the teeth and gingival tissues. This information includes:

- Integrity of teeth structures (fracture of dental hard tissues)
- Gingival bleeding (gingival trauma, luxation or alveolar bone fracture)
- Tooth alignment (lateral luxation)
- Presence of teeth (avulsion of teeth)

Results of this regarding the image quality revealed that the entire assessed image were successful, and could be used for emergency teledental services. However, the oral camera failed to give satisfactory images under some conditions like of extra lighting or head motions. Also the mobile built in camera showed poor image quality for the out of focus and head motion conditions. Results regarding use convenience revealed that the oral camera and the DSLR required 120 and 90 seconds of preparation time, respectively. Such long preparation times would make it unsuitable for emergency dental situations. On the other hand using the mobile phone, preparation time was reduced to 5 seconds, which was considered to be suitable for emergency situations. The authors concluded that regarding image quality, a DSLR camera is best, but it is less convenient to use. A mobile phone camera can give satisfactory images in the proper setting. Thus in dental emergency cases, the built-in camera of a mobile phone could be the useful instrument.

Finally, the third article that lies in this subcategory was published earlier in 2001. It was a study conducted to discuss the digital transformation of oral health care and impact scientific and technological developments have on the dentistry (33). First, the authors presented historical background of the development of dentistry mentioning the important events and factors that to lead to revolutionary changes in dentistry starting from the discovery of x-rays in 1895.

After this historical background the article focused on teledentistry mentioning the benefits and prospective outcomes of applying it as well as the implication and challenges. The study also focused on the role of internet in such digital transformation of dentistry. The article was an early attempt to draw the attention of the dental professionals about the impact of the digital transformation of oral health care showing them how the new technologies can help them and their patients. Thus, they should be familiar with such technologies and concepts to gain maximum benefits of them in their work.

Articles discussing self and home care in oral health

Maintaining good oral health can be challenge for elderly patients as well as people with intellectual disabilities. This is usually due to the difficulty of transportation and performing frequent visits to dentists. Another reason is the lack of knowledge and experience among dentists responsible of treating these groups of patients. Oral home telecare can help those patients to maintain good oral health. Teledentistry can play important role regarding home and self-oral health care. Among the articles that have been found relevant for our study three lie in this subcategory.

In 2004 a study was conducted in Japan aiming to develop a support program employing home telecare and introducing this program to the home-dwelling elderly and their families (34). The study described the home telecare program as “care service system based on interactive motion-picture transmission offering access to home health care information and enabling the acquisition of life skills under the guidance of experts”

The program consists of two systems central and terminal one. The terminal system transmitted images of the oral cavity of the elderly via an intraoral camera to the central system, as well as images of their living environments via the main camera mounted on a swivel and zoom. The tutorial program for the elderly was developed to provide information required for oral homecare, education on oral and general health care, and to enhance the elderly life skills related to exercise and interpersonal communications.

Evaluation of the outcomes of the program has been performed after three months using qualitative methods. The evaluation covered seven topics. These topics are knowledge of oral care, self-care skill, attitudes to oral care, communication ability, and impact on the community, oral and general health, and diet. In general it has been found that applying oral health care videophone-based program help to enhance the learning efficiency of home-dwelling elderly

individuals and their families, and modify their behaviors. According to the author such positive outcome was attributed to providing immediate feedback as well as the repeated exercises based on transmitted video. It has been reported that using this approach facilitated the independence of the elderly in their daily lives and at the same time it enabled monitoring from an appropriate distance and the introducing of advice from experts when necessary (35).

In 2008 a pilot project was conducted to evaluate the potential of Personal Digital Assistant(PDA) technologies aiming improve the oral health of people with mild to moderate intellectual disabilities, chronic health problems and a long-standing history of poor oral health self-care(36). It has been found that preventable oral health conditions, such as gingivitis, are more common in groups of patients with intellectual disabilities compared to general population

Oral health video and audio materials were prepared to demonstrate effective oral hygiene practices. These materials were edited, digitized and transferred to PDAs running a customized software application that controlled the standard features of the PDA so that the prompting and coaching features only were enabled. Patients were trained in the use of the PDAs at a regular dental appointment. The use of the PDA and any change in oral health status were tracked by obtaining information from direct care support staff during dental appointments and the technical support phone calls. The duration of the study was six months including two dental visits where the required information about the oral health of the patients involved in the study was gathered.

Results of this study revealed that the provided training enabled almost all the patients to efficiently use the technology and follow the oral hygiene instructions displayed on the PDAs. However, more than half of the patients had some practical problems during the study regarding keeping the PDA functioning properly. These problems were mainly related to keeping the batteries charged.

Finally the author concludes that these positive results showed the potential of using such technology to improve self-care among groups with chronic health problems. This can help to overcome the limitations of current health promotion strategies by using alternative communication strategies and customized health education and health promotion instructions using telecommunications technologies.

The third article in this subcategory of articles that discussed self and home care in oral health is a pilot project that discussed the feasibility of delivering an individualized program of oral home

telecare training using PC-based, real-time interactive videoconferencing via the Internet to meet the challenges of dental care for people with tetraplegia (37).

Studies revealed that tetraplegic patients tend to have more dental plaque and gingival inflammation due to the difficulties in performing oral hygiene (38,39). It has been found that tetraplegic patients are less likely to brush daily or to floss their teeth. Moreover, the condition of oral hygiene of those patients can be worsened as well due to the xerostomia caused by medications that tetraplegic patients take to reduce muscle spasm. This increases the chance of dental caries and periodontal disease which can lead to some severe complications for the tetraplegic patients.

Impairments of breathing musculature including the diaphragm of people with tetraplegia cause a significant reduction in respiratory function and coughing efficacy (40). Thus the increase of dental plaque deposits from poor oral hygiene and severe periodontal disease may lead to colonization of respiratory pathogens in the oropharyngeal region (41) which in turn lead to micro-aspiration of oropharyngeal fluids containing oral pathogens that increase the risk of developing a lower respiratory tract infection. This shows the importance of tetraplegic patients' maintenance of good oral hygiene to avoid such complications and risks.

In this feasibility study a home-based videoconferencing method was tested with two adults with tetraplegia and an occupational therapist. In order to improve independence in performing oral hygiene, adaptive devices were introduced as part of the rehabilitation training. The used adaptive devices are rechargeable oscillating-rotating power toothbrush and a cordless oral irrigator. These devices were used to facilitate oral care performance with interactive, web based instruction. The training was conducted once a week for 4 weeks

Evaluation of the project was performed using questionnaire and in depth interviews after the training. Results revealed satisfaction of the two patients included in the study with the oral home telecare service and their fast adaptation to videoconferencing. Moreover the electric tooth brush was identified as a positive factor. These results indicated the possibility of occupational therapists and dental health professionals to provide oral home telecare training via videoconferencing for adults with tetraplegia. Finally, the article discussed the role of occupational therapists in special care dentistry. Occupational therapists are not licensed to perform dental cleaning for the patients, but they are licensed to teach and assist patients to perform oral self-care.

More articles are required to investigate the role smart phones can play in providing adequate oral self and home care especially with the development of smart phones recently as a tool to provide teledentistry which makes it easier to use especially for elderly patients and more accessible as well as the improvement of the efficiency of smart phones camera which facilitate sharing of high resolution images.

Articles discussing the economic outcome of applying telemedicine in dentistry and the legal challenges of the implementation of such applications

Among the articles that have been found relevant for our study two lie in this category. One of them presented economic evaluation of specific teledentistry project in UK and the other article discussed some of the legal aspects regarding applying teledentistry in practice.

In 2002, a 12-month trial study was conducted where teledentistry system was implemented in two general dental practices in Scotland (one in the Orkney Islands and one in the Scottish Highlands at Kingussie) (42). The teledentistry system consists of PC-based videoconferencing link at the dental practices, connected by ISDN at 128 Kbit/s, to a restorative specialist at a hospital in Aberdeen. Twenty-five patients were recruited into the trial. A cost-minimization analysis was undertaken by comparing the costs of teledentistry with two alternatives: outreach visits, where the specialist regularly visited the remote communities, and hospital visits, where patients in remote communities travelled to hospital for consultation.

Results of this study revealed that for one of the dental practice dental teleconsultations cost the National Health Service (NHS) an additional 36 per patient compared with outreach visits, but cost-savings of 270 per patient could be achieved compared with hospital visits. Results for the other dental practice included in the study showed that teleconsultations cost the NHS an additional 44 and there were cost-savings of 1.54 compared with outreach visits and hospitals visits. However patients had to pay additional costs for radiographs and photographs, and the general dental practitioner incurred additional preparation time costs. . When the value of patient time was included, there were cost-savings of around 900 per patient for the first dental practice compared with hospital visits, but compared with outreach visits teledentistry cost an additional 180 per patient. For the second dental practice there were cost-savings from teledentistry for Kingussie patients, even when the value of time was included.

The results of this trial study that was performed in 2002 did not reveal positive economic outcome for applying this teledentistry system in the two dental clinics included in the study.

However, the authors estimated that cost-effectiveness of teledentistry would improve when health professionals and patients will be more familiar with the teledentistry applications and the use of equipments. Moreover benefits and cost-savings would be greatest in remote communities, where patients have to travel long distances to hospital for specialist consultations.

In 2000, an article was published discussing some of the legal issues regarding teledentistry. (43) The topics that was covered in this article included licensure, malpractice, technology and ethics. Regarding licensure many US states decided that teleconsultation constitute the practice of medicine or dentistry in those states. Therefore, practitioners engaged in telemedicine or teledentistry must be licensed in each state in which they practice, 20 states have restrictive licensure laws that require the health care practitioner to obtain a full license to participate in teledentistry within the states. On the other hand, at the same time 27 states and the District of Columbia did not have any law requiring licensure for the practice of teledentistry.

Then the authors discussed the principles of malpractice in medicine and dentistry and then examine these principles with respect to teledentistry consultation. Regarding the technology issues patients should be informed about the nature of the teledentistry referral and the risks associated with the electronic transfer of information. The main concerns here regarding the technological issues according to the article are privacy security and public protection

Finally the authors recommend that dentists who choose to include teledentistry as part of their practices should educate themselves about the legal, technological and ethical issues that are a part of this new aspect of their practice medium. Moreover they should be quite aware of the legal requirements in their states where they are practicing and keep themselves updated regarding the legislative changes.

The two articles in this category have been publishes in the early 2000s .More updated articles are required to cover the economic aspect of applying teledentistry in dental practices as well as the legal barriers that face such applications.

Articles discussing applying telemedicine in dental education (n=11)

This category includes articles that discussed application of teledentistry in dental education. Among the articles that have been found relevant for our study eleven lie in this category. Six of these articles are discussing applying specific tele-education system or application in dental education. Four of these articles are discussing tele-education in orthodontic field in particular. In

addition, there is one article that discussed teledentistry and its use in dental education in general. Regarding the countries where the studies were conducted, five of these articles were conducted in USA, four in UK and one in each of Finland and Sweden.

According to the article published in 2003 by Chen J et al. discussing teledentistry and its use in dental education in general, teledentistry in education can be divided into two main categories web-based self-instruction and interactive videoconferencing (44).

-Web-based self-instruction: In this education system information has been already developed and stored before the user starts using the program. The main advantage of this system is the user control over the learning process and the ability of repeating review of the material .On the other hand, lack of face to face interaction and communication with the instructors can cause degree of satisfaction (45). Moreover, results of study of electronic mail-based oral medicine consultations revealed that accuracy of diagnosis of oral mucosal pathoses using transmitted descriptive patient data was less than the face-to-face patient examinations (46).

-Interactive videoconferencing: Interactive videoconferencing is conducted via satellite, ISDN, Internet or Intranet) and it includes both a live interactive videoconference and supportive information regarding the patient such as patient's medical history and radiographs) that can be sent before or at the same time of the videoconference. The main advantage of videoconferencing compared to web-based self-instruction is the ability of the user to get immediate feedback. Because of this features ,the authors concluded that

The feasibility of teledentistry education is affected by the type of network connectivity which is chosen by the health care professionals based on budget, geography and available technical support. Finally the authors discussed some barriers that face using teledentistry in education which includes:

- Licensing and legal restrictions which differs from one state to another.
- Maintaining teledentistry courses which needs which requires fast and cost effectiveness efforts.
- The need of experienced instructors capable of designing protocols, instructing students and providing necessary technical support.

Articles discussing specific tele-education system in dental education

Among the articles that have been found relevant for our study six lie in this subcategory. It includes articles discussing the specific using of teledentistry in dental education. Articles discussing the use of teledentistry in dental education in the orthodontic field are included in separate category that will be discussed later.

In 2001 a study was conducted in the UK to assess the feasibility and practicability of videoconferencing in dental postgraduate education (47). The study assessed a pilot regional online videoconferencing project known as PROVIDENT. The assessment was obtained by questionnaires, interviews and videotapes for the twenty seven teachers included in the study. The teachers were from the 4 London Dental Schools. Forty-one postgraduate videoconference teaching sessions were provided. The subjects that were selected in these sessions covered wide a range of dental specialties including prosthodontics, periodontics, endodontics, oral surgery, orthodontics and pedodontics. Videoconferencing was carried out using a relatively inexpensive personal computer system link using ISDN2 telephone lines.

Results of this study revealed that teachers largely enjoyed the experience and performed well in the new medium. They adapted rapidly to the new medium and considered the additional work required to provide teaching by videoconferencing minimal. However, there were significant problem regarding the sound quality. Improvements in sound quality would allow a rapid expansion of postgraduate dental education by videoconferencing

In 2003, as study was conducted in Malmo University in Sweden to investigate the Feasibility of and satisfaction with the use of low-bandwidth videoconferencing for the examination of undergraduate students (48). Thirty-nine second-year dental students were included in this study. The students were divided into two groups; Students of one group were examined through the standard class procedure while students of the other group were examined through Internet-based videoconferencing. The students' evaluation of the examination medium was obtained by questionnaire.

Results revealed that the interactive examination technique was well accepted, although there was significantly less satisfaction in the videoconference group compared to the students who were examined in a classroom. Authors of the study assumed that lower acceptance of videoconferencing as a medium for examination is related to the examination stress factor. The

face-to-face contact with the examiner during the examination can play a role in reassuring the students and relieve some of the examination stress.

In 2006, a study was conducted in Finland discussing the use of teledentistry in dental specialist education in Finland (49). Specialist dental services are available very unevenly in Finland. Some smaller towns and sparsely populated regions lack some of these services. According to the Finnish National Committee of Dental Specialist Education “the need for new dental specialists in Finnish health care centers in the next ten years is much greater than current specialist training programs can produce” (50). This increases the importance of the role teledentistry can play in the dental specialist education in Finland.

The aim of this study was to determine how information and communication technologies could be used in dental specialist education in order to reduce travel and increase the interactivity between teachers and students. To achieve this, a teledentistry project started in 2002 and was concluded in 2005. In this project, university lectures were transmitted to various training locations using IP-based videoconferencing, lectures and seminars were carried out twice a week and assessment of the project was obtained using questionnaire in which the students involved in the study were required to rate the quality of picture and sound on a 4-point scale. Also, cost analysis was performed to determine the economic outcome of the project implementation.

Results revealed that the overall rating of videoconferencing as a tool in specialist training was excellent in 15%, good in 62%, neutral in 15% and poor in 8%. Moreover the overall potential cost saving per student was estimated to be at least € 43,600. In conclusion, the study suggested that videoconferencing is suitable for long distance learning in dentistry. The telemedicine tools have the potential to increase the total number of dental specialist trainees and specialists in sparsely populated areas.

In 2008, a study was conducted to evaluate the use of webcasting and podcasting in undergraduate and continuing dental education (51). Webcasting has been defined as “broadcast video, live or on-demand, using streaming technology across the world wide web to offer the ability to deliver good quality imaging within any chosen learning environment”(52). Taking video streams and transmitting them over the Internet allows students in many different remote locations to gain access to different seminars and lectures sessions. These videos can be stored on PC and watched by students later and used for revision purposes as well. The article also discussed delivering lectures and other educational material via podcasting taking advantage of the growing popularity of downloading music onto MP3 players, iPods or similar equipment.

The study then presented two web casting projects and discussed them in details. The first webcasting project was carried out at King's College London Dental Institute to compare the use of videoconferencing with webcasting and webcasting in different settings and with different presentations. The project was divided into three phases with different complex screen components.

1. Videoconferencing and one-frame webcasting across a LAN (local area network)
2. Two-frame webcast across the LAN, the second frame containing PowerPoint slides controlled by the student
3. Three-frame webcast across the Internet, the third frame acting as a live chat box. Alternatively, an on-demand recording of the webcast was made available on the Internet.

Evaluation of the project was obtained via questionnaires, interviews and videotaping. Results revealed lack of interaction in the one-frame webcast compared to videoconferencing. On the other hand, the addition of chat box was appreciated by students. Moreover, the ability to streaming out to the Internet to reach postgraduate dental students at home or at work allowed the participation of students from remote areas. The advantages of using webcasting in education were concluded:

- It can be performed anytime and viewed anyplace
- It can be embedded in online courses
- Facilitate interaction during the education and with time to review the answers
- The ability to replay on demand

The other project that the study presented was about the delivery of continuing professional development (CPD) in the workplace to pharmacists and dentists. The project enabled the creation of a series of webcasts for transmission across the internet to 50 pharmacies and dental practices. The webcasts were developed in rich media format including combination of audio, video and animated diagrams interactivity within the virtual learning environment. Participant reported their satisfaction with the website as a method of delivering their CPD. In conclusion, the use of web-based interactive education using a variety of rich media was considered a useful way of accessing CPD by professionals in dental practices and pharmacies.

In 2008 another study in the UK was conducted to discuss the development and benefits of using videoconferencing in dental education (53). The main advantage was reducing travel time and

costs for teachers, students, patients and clinicians. Then the articles discussed two projects in details where videoconferencing was used in dental education as case studies. The first project was a pilot regional online videoconferencing in dentistry (PROVIDENT) which has been mentioned in detail earlier (47).

The second project that was discussed in this article was the Dental Undergraduate Education by Teleconferencing (DUET) (54). In this project a videoconference link was provided to a dental practice to help the students to experience real life diagnosis and treatment through intraoral cameras integrated in the dentists' chairs. Moreover, it gave the students access to remote staff. The assessment of this project revealed that 98 % of the students included in the project rated the session as good to very good. In conclusion, the PROVIDENT, DUET showed the key role that videoconferencing can play in both undergraduate and continuing professional dental education.

In 2012, a study was conducted in the UK to evaluate remote communication versus face-to face in clinical dental education (55). In this study three communication modalities were compared:

- Audio and video using voice over internet protocol alone.(AV)
- Audio and video VoIP with the addition of a three dimensional virtual artifact (AV3D)
- Physical face-to-face (FTF)

Clinical case discussions between the learner and educators were held using the three communication modalities where the learner presented the case to get advice on the clinical management from the expert educators. Quantitative evaluation of the system was obtained using the questionnaires completed by both the learners and the educator. Moreover, qualitative evaluation was performed using video analysis of the interaction of people and artifacts.

Results obtained using the questionnaires showed that the students felt they were more able to provide more information using FTF, followed by AV and finally AV3D. Also, the educators considered the FTF modality better than the AV and the AV3D in terms of their ability to prove more information. In conclusion, physical face-to-face learning was a more effective modality for clinical case-based discussions between a learner and an educator. On the other hand, remote, internet-based discussions enabled a more relaxed discussion environment. The effectiveness of the AV3D modality depended on the interface design and the simplicity to use it. It also depends on providing prior training for the users.

Articles discussing tele-dental education in Orthodontics

Among the articles that have been found relevant for our study four of lie in this subcategory. It includes articles discussing the use of teledentistry in dental education in the Orthodontics specialty in particular. It was the only dental specialty where articles discussed using tele-education systems within it rather than discussing its use in dentistry in general.

In 2007, an article was published discussing Equipping orthodontic residency programs for interactive distance learning (56). The article covered the required infra-structure in orthodontics departments to allow applying the interactive distant learning system.

First the article presented the benefits of using such a system The main advantage of using such system for the orthodontic residency program was increasing the diversity of the content, more efficient use of the instructors time and it could also reduce the costs of residency.

Then the article discussed the technological requirements to apply this system. A dual-streaming multipoint video conferencing system is needed to allow sharing of instructions with other residency programs. A basic system would allow reception of the instruction, and an optimal system would allow originating and receiving such a conference. A detailed list of the required equipment with the approximate costs was provided in the article. Finally, the authors concluded that equipment were available to allow the use of distance education in orthodontic departments, both from distant part-time faculty members within the same department and from other schools as well.

Another study conducted in 2007 to evaluate the effectiveness and acceptability of using recorded interactive seminars in orthodontic distance education (57). First year residents at 3 dental schools were included in this study (Sydney, Australia; Winnipeg, Manitoba, Canada; and Manchester, United Kingdom). They viewed a recorded interactive seminar, then they discussed its content with the seminar leader at a distance via three methods; video conferencing, audio-only interaction by telephone and Internet chat with Net Meeting software. The resident then completed the evaluation and rated the effectiveness of the 3 methods and the degree of their acceptance for each of them.

Results revealed that videoconferencing received the highest ratings, telephone interaction came in the second place and finally internet chat came in the third place. Moreover, all the residents stated that they would like to repeat the distance education experience again. In conclusion, the distance learning based on observation of recorded seminars and follow-up interaction is an acceptable

method of instruction that can help the orthodontic residents to gain access to various materials and expert educators.

Also in 2007, a study was conducted to discuss applying distance learning to interactive seminar instruction in orthodontic residency programs (58). Orthodontics residents from 3 orthodontics departments that were included in this study participated in distance basic concepts seminars, clinical conferences, and clinical seminars via high-speed Internet connections. The residents completed evaluation forms to obtain information about their experience with this learning method and investigate their acceptability of it.

The orthodontic residents rated the educational experiences positively. Live participation in seminars via video conferencing was preferred to live observation or later observation of a recording. The authors concluded that the acceptability of the distance seminars was influenced by the instructor's personality and teaching style and how that can facilitate the interaction.

And finally, the last article in this subcategory is about a study conducted in 2012 to discuss utilization and acceptability of interactive distance learning for orthodontic residents (59). It has been proposed that sharing resources through distant education can be used to deal with the lack of full-time faculty members and maintain high-quality content in orthodontic residency programs as well. In this study a blended interactive distance learning approach was developed. It combined observation of Web-based seminars with live post seminar discussions. The aim of this project was to:

- Measure the interest in using the blended distant learning approach
- Determine the interest of both the faculty and the residents
- Obtain feedback regarding future use

Participants in this study had to read the assigned articles and then watched recording of an actual interactive seminar on a Web site and then immediately after, they participated in a follow-up with a faculty member at the participating institution or via a videoconference with the leader of the Web-based seminar. Finally, they completed a survey about their experience.

Results of this study revealed that the blended distant learning approach was effective and enjoyable. However, faculty members showed enthusiasm about the experience compared to the residents. Residents; who were adequately prepared before the seminars; reported a greater ability to learn using the new approach. In conclusion, blended distance learning was proved to be an

acceptable method of instruction that allows residents to access various experts .It supplements the traditional instructor-led training and helps in solving the problem of faculty shortages.

Articles discussing applying telemedicine in orthodontics (n=7)

This category includes articles that discuss teledentistry applications in orthodontics. Among the articles that have been found relevant for our study eight lie in this category. . Regarding the country where the studies were conducted, five of these articles were conducted in UK and one in USA and Italy.

In 2001, a study was conducted in the UK presenting a prototype teledentistry service that incorporated a PC-based expert system designed to assist in orthodontic cases (60). The importance of using such a system comes from the uneven distribution of orthodontic specialists in the UK which makes many general dental practitioners (GDPs) obliged to provide orthodontic treatment for their child patients. The aim of the system was to help GDPs through the assessment of the patient's malocclusion and ensure that all observations were made and all the data were recorded. After completing the assessment the program provided either:

- Treatment plan for the simple cases that could be treated by the GDP using simple orthodontic appliances.
- Recommendation to refer the more complicated cases to the orthodontics specialist mentioning the clinical parameters that made the referral necessary for each case.

In cases where the system recommended referring the case to a specialist the GDP created a white board file with all the details of the examination and sent it to the consultant together with images of the clinical records asking for advice. Method of file transmission between the GDP and consultant was the FTP (File Transfer Protocol), an international standard for transmitting electronic files between computers across the Internet. After sending the case to the FTP server, the GDP sent an e-mail message to the consultant to notify him of its presence. Later when the consultant finished adding his advice regarding the case, he sent it to the GDP on same FTP server. Moreover, where appropriate a videoconference was conducted.

In this study, six GDPs were included and the duration of the study was eight months. 158 cases were referred through the teledentistry system. The protocol was evaluated using structured interviews with the GDPs, forms completed by the GDPs for each case and the consultants records of all communications with the GDPs including dates and times of the videoconferences. Results

revealed that both GDPs and the consultants were satisfied with the protocol; used during the trial. The GDPs found that it was straightforward and covered all aspects of the cases they submitted.

Another study was conducted in the UK by Stephens C et al. to investigate effect of applying teledentistry advice system “TeleDent Southwest” on the outcome of the orthodontic treatment provided by general dental practitioners (61). Results revealed that TeleDent Southwest enabled them to offer a better service for their patients and use specialist services more appropriately. However, according to the authors, the information presented in this article must be interpreted with caution due to the short duration of the study and the small number of practitioners involved in it. Moreover, almost all the data are based on the opinions of the participating dentists

Moreover in 2002, Stephens C et al. conducted a study to determine the attitudes of UK consultants to teledentistry as a means of providing orthodontic advice to general dental practitioners (62). A survey was undertaken to determine if UK consultants would support the advice being provided to UK GDPs using teledentistry means. Information was obtained using questionnaires which were sent to all UK NHS orthodontic consultants. 86 % from the 231 consultants responded.

Results revealed that more than half of the consultants were interested in providing general dental practitioners with clinical diagnostic consultation using telemedicine applications. In conclusion, the majority of UK orthodontic consultants supported the concept of using teledentistry to make their advice more accessible to dentists and patients.

In 2005, Mandall N et al. conducted a study about using teledentistry for screening new patients orthodontics referrals. The study consisted of two parts. In part 1 a randomized control trial was conducted to:

- Evaluate the validity of the teledentistry system
- Evaluate whether the teledentistry system affected referral rates, inappropriate referral rates and number of failed appointments (63).

Fifteen dental practices in Greater Manchester, UK, were included in the trial. They were randomly allocated to either a teledentistry test group or a control group. Practitioners in the test group referred patients via a ‘store and forward’ teledentistry system and were evaluated clinically to assess whether the same decision to accept referral was made. This measured the validity of the system with the clinic’s decision used as the gold standard. Patients in the control group were referred using the usual letter system. Referral rates, inappropriate referrals and number of failed

appointments were then compared between the teledentistry and control groups. The definition of inappropriate referral used in this study was poor oral hygiene or referral too early. A quantitative method was used to evaluate the impact of the new system.

Results revealed that teledentistry is a good way of positive identification of patients who should be referred to a consultant orthodontist. Teledentistry could be a significant factor in reducing the inappropriate referral rate.

Part 2 of this study aimed to evaluate GDP opinion about using a teledentistry system to screen new patient orthodontic referrals (64). A cross-sectional questionnaire was used to obtain the opinions of the GDPs included in the study. 71 % of GDPs thought that using teledentistry for orthodontic referrals would be a good idea. More than half of them as well agreed that there would be implications for their surgery time, expense and equipment security. The authors concluded that GDPs generally supported the use of a teledentistry system for new patient orthodontic referrals.

Another study was conducted in the UK to investigate the opinion of general dental practitioners regarding an online orthodontic referral service (65). The study aimed to establish the profile of general dental practitioners in West Yorkshire who would refer patients online for a consultant orthodontist's opinion. Semi structured questionnaires were used to get the GDP opinions. The questionnaires sought to answer the question if the GDPs were ready to use teledentistry for orthodontic advice from consultants. The questionnaires were sent to all 91 general dental practices in Calderdale and Kirklees in West Yorkshire.

Results revealed that 46 % of the GDPs showed their interests in using teledentistry service to obtain a consultant orthodontist's opinion online. They mentioned that the reasons of such interests were saving time and achieving a quicker opinion for a practitioner regarding the treatment plan of the patients. In conclusion, less than half of the GDPs included in the study had positive response regarding the benefits of a teledentistry referral scheme. On the hand, substantial number was undecided or did not support the use of teledentistry for orthodontic referrals. The authors of the study assumed that this might be because they were unsure of their information technology (IT) skills.

In 2008, Berndt J et al. conducted a study to examine the feasibility of a general dental practitioner using teledentistry to provide interceptive orthodontic services to disadvantaged children with real-time supervision from an orthodontist (66). It has been found that, in USA many

malocclusions remain untreated in socially disadvantaged children (racial or ethnic minority, poor, rural, immigrants), resulting in a significant oral health disparity (67). This was attributed to their families' limited recourses and also to the limited availability of orthodontists in their communities (68). Thus, applying such teledentistry system can have positive impact on the oral health of these children.

The study was designed as case control series study. The study group included 30 children treated by a general dentist using teledentistry. One videoconference unit was set up at each site and connected through integrated services digital network lines, allowing the orthodontist to communicate in real time with the general dentist and the patient at chair side. On the other hand, the control group consisted of 96 children treated by orthodontic residents directly supervised by orthodontic faculty. Quantitative research approach was used in this study. Treatments were compared between groups based on the treatment durations and the used appliances. Peer assessment ratings (PAR) were made by calibrated examiners from pretreatment and post treatment orthodontic study models to quantify malocclusion severity and outcomes.

Results revealed that both the study and control group had significant improvements in PAR scores. However there were no significant differences between the groups before treatment or after the interceptive orthodontic treatment. According to these results the authors suggested that the interceptive orthodontic treatments provided by sufficiently prepared general dentists who are supervised remotely by orthodontists proved to be efficient method in reducing the severity of malocclusions in disadvantaged children when referral to an orthodontist is not feasible.

In 2009, a study was conducted in Italy to discuss the use of home tele-assistance in orthodontics (69). The study aimed to codify both a methodological and communication standard based on tele-assistance, and the emergencies that can be treated from a remote location along with the related clinical applications, limitations, and the patients' opinion on this new assistance approach.

Ten young patients aged 10-16 years were included in this study. They were equipped with a mobile videophone and after clear instructions, asked the advice of the orthodontic specialist to deal with minor orthodontic emergencies. After completing the treatment each of the children included in the study, they filled out a questionnaire on the level of satisfaction and the difficulties associated with the use of this technology.

Results revealed that most of the orthodontic emergencies can be solved at home. Examples of such orthodontic emergencies: rubber ligature displacement, discomfort due to the appliance and

irritation of cheeks. The patients included in this study considered using videophone to handle the orthodontic emergencies an easy and useful method. This could be due to the young age of the patients involved in the study which made them more familiar with the new technologies. In conclusion, sharing videos and images can be useful in the orthodontic field, as minor emergencies can be solved at home. This can help in reassuring patient and parents. Moreover, it can help in limiting visits to the dental office to the cases of real need.

Five out of seven articles in this category focused on the GDPs opinions and attitudes regarding using teledentistry application to refer patients to orthodontics or seeking for their consultations. These studies covered the GDPs acceptance of the new technologies and the new approaches.

Five out of seven articles in this category discussed studies that were conducted in UK. This could be due the shortage of the number of orthodontists in the UK. Britain has fewer orthodontists relative to its population than almost all European countries (70). Teledentistry can play a major in overcoming this problem by establishing proper communication between GDPs and orthodontics specialists. Thus, more researches were conducted in UK regarding using teledentistry in orthodontics.

Articles discussing applying telemedicine in oral and maxillofacial surgery (n=10)

This category includes articles that discuss teledentistry applications in Oral and maxillofacial surgery. Among the articles that have been found relevant for our study ten lie in this category. It has been noticed the varieties of the countries where there studies have been conducted. These countries include USA, UK, Ireland, Spain, Austria, Canada and Japan.

In 2000, a study was conducted in the UK to investigate the GDP opinions of the conventional referral system used at the time of the study and investigate the need for using telemedicine in oral surgery referrals (71). 400 GDPs in Greater Manchester were included in the study. Questionnaire was used to obtain the GDPs opinions. Results revealed that 48% of the GDPs were not satisfied with the service of their current specialist oral surgery referral site. 23% of respondents wished to improve their ability to communicate with the oral surgeon and 70% wanted involvement in the patient consultation. In conclusion, there is a need for change in the referral system for oral surgery specialist care. It was suggested that telemedicine could be efficient way to improve access to specialist oral surgery care.

In 2002, another study was conducted in the UK to investigate the accuracy of diagnosis of fractures by maxillofacial and accident and emergency doctors using plain radiography compared with a telemedicine system (72). Ten facial radiographs with fractures and 10 without fractures were viewed by eight oral and maxillofacial surgeries. Eight accident and emergency (A&E) doctors who were each asked questions about the presence and site of any fractures as well as the quality of the images and diagnostic confidence. Each radiograph was then transmitted over a teleradiology link and viewed by the same OMFS doctors who answered the same questions. Results revealed that using telemedicine system was a useful tool to aid diagnosis of most facial fractures. However, diagnosis of frontozygomatic and infraorbital rim disruption using telemedicine is less reliable than plain radiography. In all cases the need for appropriate clinical information is vital.

In 2004 an article was published presenting the introduction of an OMFS telemedicine system linking the three peripheral emergency departments to the OMFS center "hub" (73). Each of the four sites had three paired ISDN lines installed to provide sufficient bandwidth for the application together with a high quality Codec (coder/decoder) to transfer images from the referring Station to the receiving Station. According to the study this system succeeded in making the patient transfer procedure more appropriate. Moreover, it developed the skills of the ER medical staff, and led to an overall improvement in the early-stage management of this group of patients.

In 2005 a study was conducted in Austria presenting a summary of experiences from 50 telemedically supported treatments in craniomaxillofacial surgery in the duration from 1996 to 2002 (74). Furthermore, the study discussed applying for the first time the innovative UMTS (universal mobile telecommunication system) for the transmission of arthroscopic videos of the temporomandibular joint and other craniomaxillofacial structures. This study was composed of 4 technical system configurations:

- Integrated services digital network (ISDN)-based videoconferencing without remote control of the navigation computer
- Transmission control protocol/internet protocol (TCP/IP)-based interactive teleconsultation via bundled ISDN lines (including remote control of the navigation computer)
- TCP/IP-based interactive teleconsultation via network
- Combination of TCP/IP-connection and ISDN-based videoconferencing

Results revealed that telecommunication technology can contribute to a quality improvement in cranio- and maxillofacial surgery because of the global availability of specialized knowledge. The required technical expenditure for teleconsultation depends on the infrastructure that is already available at the clinic and the remote site. UMTS is a promising technology with the potential to be valuable in numerous craniomaxillofacial applications.

In 2010, a study was conducted discussing extending multidisciplinary management of cleft palate to the developing world using innovative applications of technology to overcome the shortages of healthcare resources which prevent providing the most basic care to those with a cleft palate (75). Such applications can facilitate the delivery of speech therapy, evaluation of audiometric data, and limited dental evaluation for these patients with a modest financial investment. Internet based modalities can be used in the preoperative evaluation and postoperative care of patients with cleft palate in the developing world.

In 2011, a study was conducted in Ireland discussing the electronic follow-up of facial lacerations in the emergency department (76). Closing the feedback loop is important for the trainees as it allow them to see what their closures look like with time and then they may be able to change their technique accordingly. Sometimes problems may develop despite a good closure. For example secondary infection, further trauma or poor wound care and that all may lead to an adverse outcome. However, lacerations are not routinely followed up in the emergency department in University College Hospital, Galway, Ireland where this study was conducted. Instead, patients were discharged to the care of their primary care physician for follow-up and suture removal. This did not allow the operators to get feedback of their in a lack of feedback for the operator of their closures and placed a barrier between the patient and scar revision services. To overcome this electronic follow system was used where consecutive patients who were sutured by a single operator using the same technique were asked to send a photograph of the laceration six months and 12 months afterwards. The patients had internet access and a digital camera, or a mobile phone with a camera. Fifty patients were included in the study. A reminder telephone call was made to each patient at six months and 12 months, and the email address or mobile number to send the picture was given again. In each telephone call patients were asked to grade the healing on a 5-point scale from 1= very happy to 5= very unhappy.

Results revealed that after six months, 23 patients stated that they were happy and 27 were very happy with the scar. At 12 and 13 months, four patients were happy and 46 very happy. However, despite the reminders, no patients sent a photograph. The results provide no evidence to support

the use of photographs sent by email or text message for the follow-up of facial lacerations sutured in the emergency department.

In 2011, a pilot study was conducted in Spain discussing management of impacted third molars based on Telemedicine (77). The study described the preliminary results of using a store-and-forward telemedicine system (SFTMS) as a tool for the pre-surgical management of impacted third molar pathology. The study was conducted at the Oral and Maxillofacial Surgery Unit of Virgen Macarena University Hospital (Seville, Spain) and 4 primary care areas located between 15 and 95 km from the hospital. The duration of the study was 12 months. 97 patients were enrolled in the study. Results of this study revealed the effectiveness and accuracy of using SFTMS as a preoperative tool for the impacted third molar pathology. It has been found that using such a system helped to avoid unnecessary visits to the hospital as well as shortening the waiting intervals. However more studies are required to establish the clinical and economic advantages of using such telemedicine, against the conventional pre-surgical management systems.

In 2012, the authors of the previous study conducted another study to evaluate the effectiveness of using a store-and-forward telemedicine system (SFTMS) as a tool for the management of patients with TMJ disorders (TMJD) referred from primary care sites to the Maxillofacial Surgery Unit (hospital-based) (78). Results revealed that telemedicine provided correct diagnosis and an adequate treatment for the majority of TMJD from primary care sites. Moreover applying such system helped to shorten the delay in the start of the treatment and prevented displacement and unnecessary costs for these patients.

In 2012, study was conducted in Switzerland describing a medical online consultation service regarding maxillofacial surgery (79). The study aimed to investigate whether the telemedical consultation is a useful tool in this surgical field by analyzing the content of the users' questions regarding maxillofacial surgery and studying the actions taken by the internet doctors. 204 questions were evaluated. Results revealed that the users questions focused on information about medical therapies or pharmaceuticals and about specific disease or an injury. The three most common maxillofacial surgery topics were sinusitis aphthae in the mouth and basal cell carcinoma. According to these results the authors concluded that the users understood online consultation not only understood as a first contact with the healthcare system but also as a centre to get professional further and detailed information and advice after a doctor visit, especially about chronic diseases and infections. In conclusion, online consultation can complement the traditional healthcare and conventional physician-patient relationship in maxillofacial surgery.

In 2012, a study was conducted in Japan describing a telerobotic-assisted bone-drilling system using bilateral control with feed operation scaling and cutting force scaling (80). Recently, oral surgery involving dental implants where drilling is used has become more common. However serious accidents can happen due to risky drilling process. To avoid such accidents supporting systems such as robotic drilling systems have been proposed. In this study a telerobotic-assisted drilling system was proposed.

A previous study reported the development of a robotic drilling system for dental implant surgery (81). However the system described in this study differs from the conventional system described in this previous study. This conventional system was a unilateral system, which was assumed to be applied to image-guided system. In the conventional systems the contact force was not transmitted to the surgeon. On the other hand the, in this study the conventional system was enhanced to a master–slave system by transmitting the cutting force to the surgeon, using acceleration-based bilateral control. Position tracking and law of action and reaction were achieved between the master and slave systems by the acceleration based four-channel bilateral control.

The authors described in details the technical features of the system as the following: “An acceleration based four-channel bilateral control system is implemented in linear actuators in a master–slave system for drill feeding. A reaction force observer is used instead of a force sensor for measuring cutting force. Cutting force transmits from a cutting material to a surgeon, who may feel a static cutting resistance force and vigorous cutting vibrations, via the master–slave system. Moreover, position scaling and force scaling are achieved. Scaling functions are used to achieve precise drilling and hazard detection via force sensation.”

The performances of the proposed system were evaluated experimentally. Cutting accuracy and reproducibility of the cutting force were evaluated by angular velocity/position error and frequency analysis of the cutting force. Results revealed that the proposed telerobotic-assisted drilling system achieved precise manipulation of the drill feed and vivid feedback from the cutting force.

Among the 10 articles in this category, only this study described a telemedicine system that was used in the actual operative surgical procedure. It is the only article that described the technical details of the system .Thus, more studies are required to propose and discuss using telerobotic system in oral surgery and the outcome of applying these systems and how it can help in improving the treatment outcome.

Six articles in this category discussed applying telemedicine for diagnostic purposes in oral surgery. One article discussed using telemedicine as post-operative procedure as follow up tool. In addition to one article that investigated general dental practitioners opinions regarding applying telemedicine for patient referrals. According to this, it appeared that telemedicine can play important role in the preoperative diagnostic stage. However, more studies are required to investigate applying telemedicine in post-operative procedure following the surgery.

Articles discussing applying telemedicine in oral medicine and periodontics (n=5)

This category includes articles that discuss teledentistry applications in oral medicine and periodontics. Among the articles that have been found relevant for our study five lie in this category. Regarding the countries where the studies were conducted, one article was conducted in each of UK, Sweden USA Brazil and Japan

In 2000, a pilot study was conducted to assess whether text-based electronic patient data transmission (e-mail) is a reliable source of information for the diagnostic decision-making process of mucosal oral pathologies (82). The study aimed to determine if information contained within a transmitted e-mail can be used as basis for making general recommendations for diagnostic tests and follow-up or referral plans. Results of this study revealed that face-to-face patient examination is more accurate in establishing a correct diagnosis for oral mucosal pathologies than transmitted descriptive patient data alone.

Recently in 2013, a study was conducted in Brazil discussing the same topic. The study aimed to evaluate the applicability of tele-diagnosis in oral medicine, through the transmission of clinical digital images by e-mail (83). 60 patients were included in this study. The clinical history and oral lesion images were recorded using clinical electronic charts and a digital camera and sent by e-mail to two oral medicine consultants. The oral medicine consultants provided the differential diagnosis of the cases with maximum of two clinical hypotheses for each case. These clinical hypotheses were compared with biopsy results that served as the gold standard. Results of these study revealed that in 31 of the 60 cases (51.7%), both consultants made the correct diagnosis; in 17 cases (28.3%), only one consultant made the correct diagnosis; and in 12 cases (20%), neither consultant made the correct diagnosis. Therefore, in 80% of cases, at least one consultant provided the correct diagnosis. In conclusion, store-and-forward teledentistry model using e-mail and high resolution intraoral photographs provides an acceptable index of correct diagnoses. These results showed that the use of information technology can increase the accuracy of consultations in oral

medicine. Moreover it showed that the participation of two remote experts increased the possibility of correct diagnosis.

In 2003, a pilot study was conducted in Japan discussing the development of Web-based intervention system for periodontal health (84). The study aimed to propose an effective system of public intervention for periodontal health to enable continuous intervention of dental professionals. In this study a Web-based intervention system regarding periodontal health was developed. The effects of the system in the workplace were evaluated. The system got the capacity of storing and displaying personalized oral health records including video images pertaining to toothbrush manipulation within their own oral cavities based on instructions by dental professionals. Moreover, the system enabled clients to view repeatedly movement of their own skill.

Thirteen workers of a company were included in this study. They were randomized to either an experimental or control group. The control group received face-to-face tooth brushing instruction at the company and follow-up via telephone while the experimental group received follow-up through the proposed system in addition to those components employed in the control group. Results revealed that the workers in the experimental group benefited in terms of improvements of not only plaque removal but also the periodontal health over 3 months. In conclusion, implementation of a Web-based approach for periodontal health can provide the public with remote instruction and produces additional public benefit.

In 2009, a study was conducted in Northern Ireland discussing the application of teledentistry in oral medicine in community dental service (85). The study aimed to install a prototype teledentistry system in a Community Dental Clinic linked to the School of Dentistry in Belfast. Duration of the study was 6 months. During this the feasibility of using teledentistry to process oral medicine referrals to a Belfast hospital consultant was assessed. This involved patient assessment by the community clinician, remote from the consultant. The study presented series of patients with oral mucosal problems who had high quality clinical photography of their lesions taken in primary care and then viewed online by an oral medicine specialist. This replaced the traditional referral pathway whereby patients travelled to see the hospital consultant.

The study demonstrated that using teledentistry in the management of patients with oral mucosal disease can work successfully. It has been found that using teledentistry is especially suitable for management of referrals of older dependent adults who have oral mucosal diseases. However, the authors recommended that more researches should be undertaken to evaluate the cost effectiveness

of using a community based teledentistry service for the management of oral mucosal disease, in comparison to the traditional consultant led hospital based approach.

In 2012, a study was conducted in Sweden presenting a telemedicine system which offered consultations with specialists at the Department of Oral & Maxillofacial Surgery at Uppsala University Hospital (Uppsala, Sweden) to dentists in the public dental health service (86). The aim of applying this system was to improve the skills of the participating dentists and dental hygienists, and save time and money for patients, healthcare authorities, and society. In this telemedicine system patient records are collected in a database for demonstration and discussion. Both medical and dental photographs and x-rays are digitized in the same system. These can be viewed during telemedicine rounds and by the consultants at the hospital before consultation. Secure, interactive conferencing software was used to allow easy and effective sharing of video and data over the internet. Conference phones were used for verbal communication. Results revealed that applying this telemedicine system allows patient care to be provided rapidly and more economically. Finally the authors of the study discuss the future plans of developing this system by using a video camera that would be installed by the chair side to allow real-time information about the intraoral conditions of the patient

The diagnostic decision making process in oral medicine depends in many cases on the shape and size of the oral lesions. This enables applying the store and forward concept in oral medicine. Asynchronous teleconsultation can be used without the need of video conferencing synchronous mode of teleconsultation. This was appeared as four out of five articles that lies in this category described teledentistry systems based on transfer of mails and clinical photographs between the general dental practitioners and the oral medicine specialists.

Articles discussing applying telemedicine in prosthodontics, restorative and pediatric dentistry (n=8)

This category includes articles that discuss teledentistry applications in prosthodontics, restorative and pediatric dentistry. The articles related to these 3 different specialties of dentistry were put in 1 category due to the small number of articles that has been found relevant for our study in each of these specialties. Among the articles that have been found relevant for our study eight lie in this category. Regarding the countries where the studies were conducted, , 2 articles were conducted in USA, 2 articles were conducted in Germany and one in the UK, Finland, Portugal and India.

In 2000, a study was conducted to evaluate using of teledental PC videoconference link in the delivery of a restorative dentistry service to remote dental practices in Scotland (87). The study aimed to evaluate teledental consultations at the interface between primary and secondary care, between general dental practices in Highland and Island communities and the restorative dental consultant in Aberdeen. PC-based videoconferencing equipment with digital cameras was used to provide diagnostic clinical and radiographic images. This pilot system provides a low-cost service combining live videoconferences with store-and-forward imaging. The system contains encryption equipment, an electrical patient record system and an HWML viewer. HWML (Health and Welfare Markup Language) is a variation of XML. It is designed for exchanging patient data between different patient record systems. The HWML viewer is designed for viewing HWML records in medical facilities or at a patient's home. Moreover, encryption system was employed to transfer data safely over the internet. It uses a one-time key for each transaction.

According to the authors the goals of applying this telemedicine system were to:

- Improve access to specialists to provide diagnosis and treatment advice;
- Reduce costs to the service and the patients;
- Reduce the isolation of practitioners by providing contact and support from specialists as well post graduate education.
- Improve the quality of care.

In 2008, a comparative study was conducted in Germany discussing using telemedicine for pre-implant dental assessment (88). The aim of the study was to evaluate using real-time telemedicine in exchanging expert opinions in the area of pre-implant dental assessment. Duration of the study was two years. During this period every tenth patient at the armed forces' dental clinic in Cologne-Wahn seeking implant counseling was discussed via videoconference. Indications, prosthodontics options, the required number of implants and implant positions were determined.. The study group included 85 patients while the control group; where the implant consultation was performed based on existing records, without using telemedicine.; included 772 patients.

In the study group, a basic change in the prosthodontics concept was required in 3 % of the cases while the number and position of implants changed in 15 % of the cases. In the control group, the change of the prosthodontic protocol was required in 7 % of the cases while the number and position of implants changed in 19 % of the cases. These results showed that telemedicine allowed preoperative evaluation of implant operations. Telemedicine evaluation of the diagnosis, surgical-

implant treatment protocol and prosthodontic protocol appeared to be as good as evaluation based on existing records.

In 2010, a study was conducted in Finland to investigate whether videoconferencing could be used for diagnosis and for making treatment plans for patients who need prosthetic or oral rehabilitation treatment (89). The duration of the study was 13 months. 24 patients and 25 dental professionals (18 dentists, 2 dental hygienists and 5 nurses) were included in the study. The consultations took place between a specialist dental treatment unit in a central hospital and general dental practitioners in seven regional health centers. Users' satisfaction questionnaire was used to obtain the dentists and patient opinions regarding the telemedicine system.

Results revealed that all the participating dentists were satisfied with the consultation process and indicated that the technology used was of sufficient quality for clinical purposes. Moreover, patient satisfaction questionnaire indicated the patients' satisfaction regarding the proposed system. These Results showed that videoconferencing can be used for diagnosis and treatment planning for patients requiring prosthetic or oral rehabilitation treatment with demanding problems. Applying video consultation in dentistry can play a role in increasing the total number of dental specialist services in sparsely populated areas, such as those in Finland.

In 2011, a comparative pilot study was conducted to evaluate the effectiveness of tele-guided interceptive prosthodontics treatment in rural India (90). Resorption of the residual ridges following tooth loss is a major oral health problem in India. This resorption leads to irreversible loss of bone volume of the jaws which undermines retention and stability of future dentures. However one of the procedures that can be used to stop the resorption and provide retentive dentures is the construction of over dentures that are anchored to modified tooth or roots. This requires skilled prosthodontics specialists who are concentrated only in urban areas in India while rural areas suffer from shortage in number of such specialists. The study aimed to investigate if general dental practitioners were able to fabricate over denture under remote guidance from specialists.

Patients included in this study were divided into 2 groups. Study group which included patients attending a rural dental health clinic and control group including patients attending a university teaching hospital. In both groups the treatment were carried out by general dental practitioners. However in the study group the operators were guided remotely over a telemedicine link, cell phones, and emails while in the control group they were guided directly by the specialists. At the end of the treatment period the technical quality of the dentures was evaluated by carrying out

functional assessment of the dentures. Subjective evaluation was carried out by the patients completing the Oral Health Impact Profile (OHIP-EDENT) questionnaire before and after treatment. Results of the study revealed that remotely supervised general dentists can provide over-dentures of sufficient quality to rural population. Applying this telemedicine consultation system can improve access to care and elevate the level of dentistry available to rural population when referral to specialists is not applicable.

In 2011, a preliminary study of teledentistry was conducted in Germany discussing recognition of root canal orifices at a distance (91). Fifty images of endodontically accessed teeth acquired with an intra-oral camera were assessed to evaluate the remote recognition of root canal orifices. The images were stored on a laptop computer and were presented to 20 observers who marked the visible canal orifices using software which stored the canal locations in standard files. Following verification of the marked position using histological slice, results revealed that in 87% of the cases, the canal locations were marked correctly. It has been found that the detection rate was related to the professional experience of the observers as the maximum proportion of accurate detections was found for the observers who got more than 10 years of professional experience. In conclusion, remote recognition of root canals by experienced dentists can help younger colleagues in the detection of root canal orifices.

Among the articles that have been found relevant to our study, 3 discussed applying telemedicine in pediatric dentistry. In 2006, a study was conducted in USA presenting teledentistry project that was applied in inner-city child-care centers in Rochester, NY (92). In this project, telehealth assistant recorded the digital images of children's teeth using intra oral camera. The images were sent to a computer at the expert dental site. The pediatric dentist at the expert site reviewed the images and provided referral and treatment recommendations. Subsequently, the telehealth assistant contacted the child's parents and assisted them to obtain appropriate dental care for their children. Teledental screenings of children attending inner-city child-care centers who included in the study revealed that almost 40% had active dental caries many children have had their teeth examined for the first time. They were given prompt feedback on the need for dental care. These results showed the teledentistry can play in improving the dental health of pre-school children, particularly children without adequate access to dental care.

In 2009, a study was conducted in Portugal discussing the remote diagnosis of children dental problems based on non-invasive photographs (93). The study aimed to investigate the role teledentistry can play in early diagnosis of dental problems of children using accessible and low-cost technologies and evaluating the validity of such diagnosis which was based on non-invasive

photographs. Three photographs were taken for each of 66 children included in the study. These photographs were remotely analyzed by four dentists. Each dentist filled a web-based questionnaire for each child. The same children had a traditional in-person dental consultation that is used as a gold standard in this study. Results of the study show. The positive predictive value was between 67% and 100% and the negative predictive value between 94% and 100%. These results indicated that that the remote diagnosis of children dental problems based on non-invasive photographs can be a valid resource in cases when referring the children to specialists is not available.

In 2011, a comparative study was conducted to assess dental caries prevalence and dental care utilization in pre-school children enrolled in urban childcare centers (94). Children included in the study were randomized into two groups: control group where children received a traditional oral examination and study group where children received a teledentistry examination. Information about using dental and medical service as well demographics information was obtained from the children's parents using questionnaires. Results showed that the mean decayed and filled tooth surface (DFS) score for the children examined by means of teledentistry was 1.75 and for the children examined by means of the traditional visual/tactile method the mean DFS was 1.40. The means between the two groups were not significantly different. Moreover, results revealed that 28% of the children had caries and 61% of those children with carried had never been treated for caries before. In conclusion, continued efforts and applying new approaches like teledentistry are needed to improve oral health care utilization by inner-city preschool children.

The eight studies that lie in this category focused on using telemedicine applications for the purpose of communication and consultation between general dental practitioners and specialists. More studies are required to cover other aspect of applying telemedicine in prosthodontics and restorative and pediatric dentistry. Only three studies have been found in this review discussing using telemedicine in pediatric dentistry as well as three articles discussing applying telemedicine in prosthodontics and two articles were discussing applying telemedicine in restorative dentistry. It has been noticed the shortage of articles that covers applying in these specialties compared to articles that discuss applying teledentistry in general or discuss applying teledentistry in orthodontics, oral surgery or for the purpose of dental education.

DISCUSSION

During the research of teledentistry literature that was conducted in order to identify the relevant articles, 5 reviews of literature studies about teledentistry were found. Although those articles were not included in our study, the fact of the presence of only 5 teledentistry reviews compared to large number of reviews studies covering telemedicine revealed the need of more reviews studies to highlight the emerging areas of teledentistry and trying to draw a complete picture about this alternative and innovative method of delivering dental care. These 5 reviews studies were conducted in the last 4 years with two of them having been published in 2013 which showed that researches started to draw more attention towards conducting this kind of studies recently.

After searching for teledentistry literature in the previously mentioned electronic data bases using the specific keywords mentioned in the method chapter, 294 Papers have been identified before applying exclusion and inclusion criteria excluding the duplicated. By performing quick search on July 2013 for telemedicine literature in general in the “Pubmed” electronic data base only we found 15909 articles. This revealed the small percent of articles discussing teledentistry among articles discussing telemedicine in general. The nature of dentistry differs from other medical specialties so studies on applying telemedicine in most cases cannot be applied on teledentistry and researches that discuss in specific applying telemedicine in dentistry are required to investigate the potential outcome and the barriers facing such applications. It is also required to investigate the dentists’ as well the patients’ acceptance of this alternative mode of dental care delivery.

Few reasons might be behind this small numbers of published articles discussing teledentistry. The relatively late start of research regarding applying telemedicine in dentistry compared to other medical fields could be one of the reasons. Only in the mid-90s teledentistry started to develop in Western Europe and USA .It began in USA in 1994 by the military project “Total Dental Access (TDA) which aimed to improve patient care, provide continuing dental education and establish dentist–laboratory communications. (3)

Another reason that could be behind the markedly neglecting of conducting researches dealing with use of telemedicine in dentistry compared to medicine, is the availability of required infrastructure including the equipment to start teledentistry systems. The economic factor and providing the sufficient funds to provide such infrastructure played important role and this

depends on the dentists acceptance of the teledentistry concept and the role it can play to improve the outcome of the dental service as well the economic benefits of applying such systems.

It has been found that only one article relevant to our study was published focusing exclusively on economic outcomes of applying telemedicine in dentistry. It was a trial study discussing the economic evaluation of a specific teledentistry project in the UK in 2002. (42) Economic outcomes of applying teledentistry have been discussed briefly in some other articles but without focusing much or getting into details. More studies are required to focus on the economic outcome of applying teledentistry and teledentistry potentials of reducing cost of oral health by sharing recourses. The positive economic outcomes; in case it was proved by valid scientific researches; can play a role in the encouraging for providing more funds for the teledentistry projects and increase dental professionals acceptance of teledentistry.

Technology Acceptance

Regarding dental professional acceptance of teledentistry, a few articles that had been found relevant to our study investigated the dental professionals` opinions about using telemedicine applications in dentistry or their satisfaction about newly implemented specific teledentistry systems. Such investigation were performed using different methods including questionnaires and interviews in an attempt to distinguish if applying teledentistry had positive effect or not on the diagnostic process and the treatment outcome and comparing that with the diagnostic process and treatment outcomes using the conventional methods. Also the dentists` opinion about the effects of applying teledentistry on saving time and money had been under investigation in these studies.

Questionnaires were used as well to get information regarding the patients` opinion about the effects of using teledentistry on facilitating the dental care delivery and meeting their goals in seeking care. An example of this was investigating the satisfaction of patients living in rural areas where access to dental care is difficult regarding using teledentistry project applied by the University of Minnesota (27).

Moreover studies that discussed using telemedicine for the purpose of dental education, had investigated the students` opinions about using applying teledentistry in dental education and evaluate their satisfaction about applying this alternative way of education compared to the conventional method (45, 47, 48, 49).

However , in addition to using questionnaires and interviews to evaluate the the dental professionals, using the technology acceptance module theory can help us to get better

understanding of the degree of acceptance of using teledentistry systems and the kind of barriers that might affect such acceptance. Understanding the procedures of acceptance of newly implemented technological systems in specific work environments can play important role in the success of such system. The Technology Acceptance Model(TAM) is theoretical model from the field of Information System. It is an adaptation of the Theory of Reasoned Action and is tailored for modeling user acceptance to the field of Information systems. The designers of the theory aimed to understand why people accept or reject information technology and understand impact of external factors on internal beliefs, attitudes and intentions. (95) The two main determinants in the TAM theory are the perceived usefulness and perceived ease of use (96).

None of the studies that have been found relevant to our study applied the Technology Acceptance Model Theory on teledentistry, thus conducting research on teledentistry using the TAM as theoretical framework is recommended and it can help to explain the relatively small number of articles discussing teledentistry compared to the telemedicine literature in general and the reasons that these articles focused on specific dental specialties at the same time where there is shortage of studies that discuss applying teledentistry in other dental specialties.

Information Infrastructure Theory

Information infrastructure theory was chosen as a theoretical framework to be applied on the findings of this review of literature. In the case of teledentistry and from the observation obtained from the articles included in this review the infrastructure of teledentistry system might include:

- i. Equipment such as the computers, high speed internet, printers, scanners, intraoral digital cameras, efficient videoconference systems
- ii. Information which can be the patient dental records, their medical history, patients` x-ray imaging and the patients` personal data.
- iii. The network communication standards and transmission codes that facilitate interconnection and interoperation between networks.
- iv. The teledentistry system designers, who create the information, develop applications and services, construct the facilities, and train others to use it.

Information infrastructures are more than pure technology but rather socio-technical networks. They include technological components, humans, organizations, and institutions.

As has been explained earlier in the Methods chapter, understanding of the concept of information infrastructure and analysis of its core components can be the key factor of successful implementation of information and communication technology system (ICT) within a certain organization and in our case in this review it can play a major role in successful implementation of teledentistry system.

This review included articles that were published starting from the year 2000 until March 2013. It has been noticed from the articles that were published during this period and found relevant and included in the review the advances in the used technology and ways of communication throughout the recent years. This technological development play a major role in facilitating the implementation of teledentistry systems and improving the efficiency of these systems. This is reflected on the results of the studies that show better outcome and more acceptances by the users. The majority of articles included in the review discussed applying teleconsultation systems that allow communication between GPs and specialists to reach the proper diagnosis and improve access to dental specialists to accelerate diagnosis and treatment.

High speed internet, efficient videoconference systems and highly advanced digital radiography and clinical photography tools represents the basic infrastructure of such teleconsultation systems. The current availability of these kinds of infrastructure with relatively low cost are reflected in the increase in the number of studies focusing on this aspect of teledentistry. The majority of these studies were conducted in developed countries in (USA, Europe and Japan) with only 3 studies relevant to the review were conducted in developing countries which reflects the main barriers that face implementation of teledentistry in developing countries which is the availability of the required infrastructure.

On the other hand, there is a shortage of articles that discuss using of teledentistry in the operative or surgical phase in dentistry. Such a kind of teledentistry system requires highly advanced and expensive technology including robotic surgery for example. There are more studies recently discussing applying such technology in medicine including general surgery. It is expected in the future when these technology become more available, cost less and been subjected to further studies within the medical field to be incorporated and studied more in the dental field.

As mentioned in the method chapter, Star and Ruhleder in their explanation of information infrastructure concept, they put more emphasis on the social relations constituting infrastructure explaining its different dimensions (25). Applying this on teledentistry will lead us to the

importance of organizational structure where the teledentistry is applied whether it is hospital, private clinic or dental school.

Moreover, it shows the importance of the human factor in order to achieve successful implementation of the teledentistry system. This is reflected on the large number of studies that investigate the user's acceptance of specific teledentistry system. In most cases questionnaire method was used to obtain information regarding the GDPs and the specialists' opinions and attitude towards applying new teledentistry system. In case of the studies discussing applying teledentistry in dental education the opinion of the students regarding the new implemented systems were also under investigation. Focusing on the technological aspect without giving much attention to the social aspect might lead to the failure of implementation of the teledentistry system.

Analysis of the obtained data about Years of publication, Countries where the studies were conducted and the Dental specialties in which teledentistry were applied

Despite this small percent of articles discussing teledentistry among the articles discussing telemedicine in general, it has been noticed increase in the number of articles in recent years. For example among the 53 articles that has been relevant to our studies, 8 of them were published in 2012 and 17 were published in the last 3 years .This showed the increase of rate publishing articles discussing teledentistry recently. This can be attributed to extensive technological innovation in the field of dentistry in the recent years. Such technological innovation can be observed in the advanced using of computers in dentistry as well as the telecommunication technology, electronic patient records and digital diagnostic imaging. This provides the bases of any successful teledentistry system. Moreover, with such rate we expect that during the following years there will be more increase in the number of studies concerning teledentistry.

Regarding the countries where the studies relevant to the review of literature were conducted, it was found that the studies were conducted in Fifteen different countries. The USA came at the first place with the largest number of studies (n=18) followed by the UK (n=15). However it also noticed in specific categories the majority of the studies were conducted in UK. Five out of seven articles discussing applying teledentistry in orthodontics were conducted in UK. This could be due the shortage of the number of orthodontists in UK. Britain has fewer orthodontists relative to its population than almost all European countries.(70) Teledentistry can play a major in overcoming in this problem by establishing proper communication between GDPs and orthodontics specialists.

Another observation regarding the countries where the studies were conducted was that 50 articles were conducted in developed countries in Europe, North American and Japan. Only 3 studies were conducted in developing countries as two studies were conducted in India discussing the use of teledentistry for providing access to specialists in rural India.(12, 90) and one study was conducted in Brazil to evaluate the applicability of tele-diagnosis in oral medicine, through the transmission of clinical digital images by e-mail. (83)

Providing dental care in rural regions in developed countries face more barriers compared to developed countries. These barriers include addition to the geographic remoteness, poverty and poor or even lack of public transportation in some regions. This leads to a compromise on the quality of dental care, resulting in complications. Teledentistry could be one of the possible options to overcome such complications.

More researches are required to discuss implementation of teledentistry systems in developing countries. Funding of implementation of these systems can be one of barriers. Thus researches should focus on cost effectiveness of applying teledentistry in developing countries and using of the available technology wisely to achieve the required goals and maximize the benefits. The main goal is using accessible and low-cost technologies to improve the dental treatment outcome and reach the patients in the underserved areas. Countries like India, Brazil and China can play major role in these researches with the significant improvement and growth of their economy in the recent years which can facilitate providing the funds for the researches. Information technology industry in these countries reaches high level of advancement. Moreover, the expansive size of the areas of these countries with high percent of its population living in geographically remote urban areas makes it ideal place for implementation of teledentistry system and investigate the outcome on the improvement of delivery of the dental care as well as increasing access to dental specialists.

Regarding distribution of the articles relevant to our studies on different dental specialties, it has been noticed the difference in the number of studies from one dental specialty to another in addition to the studies the discussed teledentistry in general and the articles discussing using teledentistry for the purpose of dental education. More studies focused on incorporating teledentistry in dental specialties like oral surgery, orthodontics and oral medicine compared to prosthodontics, restorative and pediatric dentistry.

With ten studies oral surgery is the dental specialty with the highest number of articles discussing using teledentistry in it. However six of these articles discussed applying telemedicine for

diagnostic purposes in oral surgery which revealed the important role teledentistry can play in the preoperative diagnostic phase in oral surgery. One article discussed using telemedicine as post-operative procedure as follow up tool. In addition to one article that investigated general dental practitioners opinions regarding applying telemedicine for patient referrals.

Only one article discussed a teledentistry system that was used in the actual operative surgical procedure. (80) It is the only article that described the technical details of teledentistry system. This revealed shortage of researches regarding implementing teledentistry in the operative surgical procedure compared to the preoperative diagnostic phase. This can be attributed to the highly advanced technology that is required in such systems compared to telecommunication and videoconferencing system that is required of tediagnostic purposes.

With seven studies, orthodontics comes at the second place after oral surgery regarding number of studies discussing incorporating teledentistry in specific dental specialty. This does not include the studies discussing using teledentistry for the purpose of orthodontics education which were included in this review in the category of dental education. Five out of these seven articles focused on the GDPs opinions and attitudes regarding using teledentistry application to refer patients to orthodontists or seeking for their consultations. The focus on this aspect of teledentistry can be attributed to the shortage in number of specialists in orthodontics especially in rural regions. Another reason for such focus could be the difficulties GDPs face dealing with patients with orthodontics problems without the consultation of orthodontics. However some simple cases can be handled with the GDPs without the need of referring the patients to the orthodontics in case efficient teledentistry consultation system has been applied.

Only one study focused on the clinical outcome of using teledentistry in orthodontics and measured it quantitatively (66). More studies are required to cover this aspect using quantitative methods of research to investigate the impacts of applying teledentistry in orthodontics compared to conventional methods of delivery of orthodontic treatment care.

With five articles, oral medicine comes at the third place regarding number of studies discussing incorporating teledentistry in specific dental specialty. Oral medicine is the specialty within dentistry that focuses on the diagnosis and non-surgical management of complex disorders affecting the mouth and jaws. It represents the interface between medicine and dentistry. Application of teledentistry system in the oral medicine specialty has a lot of common features with the teledermatology systems. This is due to the number of similarities in the nature of the two specialties especially in the diagnostic decision making process which depends in many cases on

shape and size of the lesions; the skin lesions in case of dermatology or the oral lesions in case of oral medicine.

As mentioned earlier in this review, such nature of diagnostic decision making process in oral medicine enables applying the store and forward concept when teledentistry is incorporated in oral medicine. Asynchronous teleconsultation can be used without the need of video conferencing synchronous mode of teleconsultation. This can be noticed from the articles included in the review discussing applying teledentistry in oral medicine as four out of five articles that lies in this category described teledentistry systems based on transfer of mails and clinical photographs between the general dental practitioners and the oral medicine specialists.

On the other hand it has been noticed the shortage in the number of articles discussing incorporating teledentistry in prosthodontics, restorative and pediatric dentistry. Among the articles that has been found relevant to our study, three of them discussed using teledentistry in prosthodontics, three in pediatric dentistry and only two discussed incorporating teledentistry in restorative dentistry. These eight studies focused on using telemedicine application for the purpose of communication and consultation between general dental practitioners and specialists.

More studies are required to cover using teledentistry in these dental specialties. In particular more researches are need on applying teledentistry in the field of dental implantology which is considered now one of the most growing dental fields where technology plays a major role whether in the surgical procedure or regarding the material used for the implants. Only one article discussing using teledentistry in dental implantology has been found relevant to our study and included in the review under the category of prosthodontics (88). Teledentistry has the potential to play a role in dental implantology whether in the diagnostic phase, the surgical phase or in the postoperative follow up phase.

In addition to the categories that include articles discussing incorporating teledentistry in the different dental specialties, the review included two more categories. One category includes articles discussing incorporating telemedicine in dentistry in general without the focus on specific dental specialty and another category which includes articles discussing using teledentistry for the purpose of dental education.

Regarding the category including articles discussing using teledentistry for the purpose of dental education, few points can be observed while studying these articles. First, it is well noticed the focus of researches on this aspect of teledentistry as eleven articles relevant to our study were

included in this category which is more than the articles discussing applying teledentistry in some dental specialties like prosthodontics restorative and pediatric dentistry all together. This can be attributed to the accessible and low-cost technologies that are required for applying teledentistry in dental education. It is mostly depend on using videoconference system and with the availability of high speed internet in the recent years which facilitate providing different departments in dental school with such videoconference systems.

Moreover ,the relatively young age of students whether they are undergraduate students or specialized post graduate residents can play a role in increasing the acceptance of applying such alternative ways of education as usually those at young ages are more familiar with using technology compared to others. However, experienced instructors are required for the success such tele-education systems. These instructors are expected to have both teaching experience and computer knowledge.

Second, among these eleven articles, four of them discussed using teledentistry for the purpose of orthodontic education which revealed the focus of using tele-education in orthodontics in specific. This can be attributed to the shortage in number of orthodontists in general and the need of training more dentists and educate them to be specialized orthodontists to fill such gap. Applying teledentistry in orthodontics education can play a role in improving the quality of instruction in orthodontic programs. It also allows good communication between different orthodontic departments in different dental schools that can help in increasing the diversity of the educational content as well allow sharing experiences and assistance between these different departments.

Despite this small number of articles discussing using teledentistry in the different dental fields, results of the majority of the articles relevant to the review achieved positive outcome after implementation of the teledentistry systems. These positive outcomes in addition to the continuous advancement of information technology and the significant increase of its availability makes us expect increase in the number of studies that investigate incorporating teledentistry in dentistry in the future and the expand of these applications into more dental specialties and as well as the different aspects of dentistry including the operative and surgical phase in addition to the consultation and diagnostic aspects.

CONCLUSUION

In the recent years extensive technologic innovations have been incorporated in the dental field. This includes the use of computers, telecommunication technology, digital diagnostic imaging services including both digital radiography and photography and use of intra-oral camera .In addition to the devices and software that have been used in dentistry for analysis and follow-up. However by searching for teledentistry literature only 53 articles were found relevant to this review which represents small percent among the literature discussing telemedicine applications in general.

Analysis and study of these articles revealed that more number of articles focused on incorporating teledentistry into specific dental specialties while incorporating teledentistry within some other dental specialties had been relatively neglected. Articles focused more on applying teledentistry in oral surgery, orthodontics and oral medicine as well using teledentistry for the purpose of dental education while specialties like prosthodontics, restorative and pediatric dentistry have been relatively neglected with fewer number of articles discussing using teledentistry in these fields. This can be attributed to the difference in the nature of these dental specialties including the diagnostic and operative procedure and post-operative procedures as well as the shortage in the number of specialists regarding specific dental specialties which requires more researches to overcome this problem and increase patients' access to dental specialists especially in rural areas. Moreover, more researches are required to focus on the economic outcome of applying teledentistry and teledentistry potentials of reducing cost of oral health by sharing recourses.

The majority of articles included in the review discussed applying teleconsultation systems that allow communication between GDPs and specialists to reach the proper diagnosis and improve access to dental specialists to accelerate diagnosis and treatment. This can be attributed to the current availability and relatively low costs of the basic infrastructure required for such teleconsultation systems including high speed internet, efficient videoconference systems and advanced digital radiography and clinical photography tools. However more researches are required to study using teledentistry in the operative or surgical phase of dentistry. The shortage of this kind of researches can be attributed to the complicated, advanced and expensive technology required for such teledentistry systems.

The majority of the articles that found relevant to this review were conducted in developed countries with only 3 articles conducted in developing countries; in India and Brazil. More researches are required to discuss implementation of teledentistry systems in developing countries. Teledentistry can play a major role in developing countries in overcoming the barriers facing providing dental care especially in rural regions.

Despite this small number of articles discussing using teledentistry in the different dental fields, the results of the majority of the articles relevant to the review showed the positive outcome of the implementation of the teledentistry systems. These positive outcomes in addition to the continuous advancement of information technology makes us expect increase in the number of studies that investigate incorporating teledentistry in dentistry in the future and the expand of these applications into more dental specialties and as well as the different aspect of dentistry including the operative and surgical phase in addition to the consultation and diagnostic aspects.

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