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TELERADIOLOGY -A Review

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ABSTRACT

The projection of health care beyond the walls of a practitioner's private office or medical center has been a sought-after dream in providing quality health care to the public, regardless of their area of residence. As this new concept, termed *telemedicine*, came about, the dream has become grounded in reality. Telemedicine has been described as the marriage of telecommunications technology with medical expertise for the delivery of health care or continuing education. Applied to various clinical disciplines, the specialty areas of teleradiology, teledermatology, telepsychiatry, telecardiology, and telepathology, among others, have been created, Teleradiology is the most common application of telemedicine and accounts for the greatest number of telemedicine consultations conducted annually.

Keywords: NIL.

INTRODUCTION

In 1994, the American College of Radiology (ACR) defined teleradiology as the electronic transmission of radiologic images from one location to another for the purposes of interpretation, consultation, or both.[1] The distance component of this definition differentiates teleradiology from the local Picture Archiving and Communication Systems (PACS) that acquire, store, manage, and display digital images within health care institutions and clinics. Teleradiology systems allow direct digital or digitized film images to be transmitted to distant locations, where they can be viewed and downloaded to hard copy for reading and interpretation.

Historical Context:

The first apparent instance of a dental radiograph being transmitted over distance was in 1920 by the Western Union Telegraph Company.[2]Although Western Union described the service to be commercially available, it was somewhat impractical for routine use.[3] In the 1950s, Gershon-Cohen and Cooley[4] reported the transmission of radiographs between two hospitals using existing telephone lines and 'a' specially modified facsimile system. They termed the process *telegnosis.* One of the first practical teleradiology projects was established in the late 1960s as reported by Murphy and Bird.[5,6]Their system was a microwave video-link between Massachusetts General Hospital and a walk-in clinic at Logan Airport in Boston.

Several telemedicine applications were included in this link, among which was teleradiology. In 1981, Gayler et al reported the telephone transmission of film based images captured by a video camera directed at a lighted view box. They described the images as being adequate for consultation but not for primary interpretation. Continuously improved, teleradiology accounted for approximately 50% of all telemedicine services delivered in the United States in 1998,[7] An estimated 7000 teleradiology units have been sold in the United States.[8] Many units are beginning to be used for primary interpretation of images without reviewing original images.[13]Others limit their use to consultations or overreads.[9]

Teleradiology consultations and referrals, in addition to other telemedicine services, are an increasingly important issue in rural health care.[10]This technology has the ability to bring the benefits of tertiary health care to any locality. Even in the urban setting, distance consultations are helpful, where transportation may present an artificial barrier to health care.[11]

Dental Applications

Teleradiology has not been used as extensively in dentistry as it has in medicine. Nonetheless, there are a multitude of actual and potential applications, including dental insurance authorization, consultations and referrals, compatibility with electronic record retrieval systems, forensic cases, electronic grand rounds, and continuing education.

Transmission of dental radiographic images requires that the image files be in a digital format. Conventional dental radiographic films can be scanned to convert them from analog to digital formats, a process termed *digitization.* Two basic types of digital dental systems are commercially available to acquire images without the need to scan conventional films. One is a direct digital system with electronic sensors using charge-coupled devices (CCDs) or complementing metal oxide semiconductors as image receptors. [12,13] The other is an indirect digital system using storage phosphor plates as image receptors. The storage phosphor system has also been referred to as *computed radiography.*[14] Postprocessing of the electronic images is possible with virtually all of these systems, which allows the practitioner to enhance, magnify, and measure the images as well as vary the contrast and density after acquisition. A variety of proprietary systems are marketed specifically for dental imaging needs, which manage intraoral (dental film sizes 0, 1, 2, 3, and 4) and extra oral (panoramic and cephalometric) image formats.

Digital systems are reported to offer advantages over film-based intraoral radiography in decreased patient radiation risk and a wider range of contrast.[15,16] Extra oral systems offer comparable patient radiation risk to film-based extra oral systems using 400-speed screen/ film combinations.

Acceptance of transmitted images by dental insurance companies has the potential of shortening the authorization time for patient treatment and speeding reimbursement to the dental practitioner. The use of digital images is also advantageous in that radiographic films cannot be lost or misplaced when loaned out or mailed for consultation or insurance review. Incompatibility of proprietary digital software, the lack of protection against inappropriate image modifications, and confidentiality of patient information, however, have slowed acceptance by some dental insurance companies and legal entities.[14,15] Currently, few dental insurance companies are equipped or encourage the submission of digital image files. It is hoped that this situation will change as the technology of teleradiology matures and the electronic transfer of diagnostic images becomes more commonplace.

Long-distance radiology consultations using transmitted dental radiographs have been successfully demonstrated on numerous occasions. Various telephone lines and satellite communications links have been used at the Texas A & M University System Health Science Center Baylor College of Dentistry to transmit images from the Center for Telehealth in Dallas, Texas, to rural health sites in the Rio Grande Valley as well as other sites in Vermont, Florida, and Minnesota. These links also included clinical presentations and histopathology consultations.

Technologic Issues

Acquisition of Images

To transmit image files, the data must be in a digital format. Conventional radiographic film, which is analog in nature, is still widely used. In early projects, analog radiographic film images were illuminated on a view box and photographed with a video camera.[16] This technique produced a digitized image that was of marginal quality compared with the original film. Today there are two newer technologies for digitization of conventional films:

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laser digitizers and CCD digitizers. Laser digitizers are considered the superior technology because of their excellent contrast and spatial resolution.

The current generation of CCD digitizers, however, now offers good spatial resolution with the added advantages of reduced cost and smaller unit size. CCD digitizers may become the technology of choice.[17]Images may also be acquired without the need for scanning analog radiographic film. Direct digital systems using CCDs and indirect computed radiography systems using storage phosphor image receptors are more efficient methods of obtaining digital images. CCD sensors acquire the images directly on exposure, and the images are available for viewing almost instantly. Computed radiography receptors require laser scanning subsequent to exposure to process the image. This extra step takes longer than the CCD systems, but the image is still available for viewing within a short period. Some computed radiography systems may require a longer processing time.[14]

Transmission of Images

Digital images may be saved in a variety of file formats in data retrieval systems for subsequent reference or transmission to another site. A commonly used format is the tagged image format file (TIFF). Although this type of file may be opened with different software programs, the file does not contain any additional information regarding the patient, orientation of the image (left versus right, top versus bottom), or acquisition date.[16]

Digital image files may be transmitted over short or long distances using a wide area network (WAN). The choice of a WAN depends on several parameters, among which are image type, number of images, data transfer rate requirements, and financial limitations. Transmission can be accomplished with common telephone lines [plain old telephone system (POTS)], cables (coaxial or fiberoptic), lasers, or microwave transmission links to communication towers or satellites.[16] The choice of transmission method is typically a compromise between expense, availability, and bandwidth. Higher bandwidths decrease transmission time and increase the capacity of the network.[16,17]

Transmission efficiency is determined by the slowest link in the network, which might be a POTS line. With a fast modem, the rate may be 28.8 Kb / s, but faster rates are possible. For a single uncompressed periapical radiograph with a file size of 300 Kb, transmission time could take 1.4 minutes. Panoramic and cephalometric images, with file sizes of 6 to 8 Mb or more, could take several minutes (Table 1). Transmission time depends on network infrastructure and workload and is variable.

More optimally, an integrated service digital network (ISDN) or DS-1 carrier is used for communication links in a WAN with transmission rates of 1.5 Mb / s to 2.0 Mb / S.33 ISDN is a network standard that provides service through a limited number of standard digital interfaces and is widely available in urban areas of Europe and the United States. ISDN is still inaccessible in many rural areas, however. Another standardized service, DS-1, is used in the United States and Japan but has no identical European standard. The transmission line facilities provided by the carriers for DS-1 service have an identical bandwidth called *T-l;* the two designations are used interchangeably. A developing new standard is the asynchronous transfer mode (ATM) network. ATM offers wide bandwidth with transmission speeds as fast as 155 Mb/s but is not yet widely available in Europe or the United States.[4,9,18]

File Size and Transmission Times at Various Speeds*

		Transmission Time			
Image Projection	File Size	POTS Line (28.8 Kb/s)	POTS Line (56 Kb/s)	DS-1 Line (1.5 Mb/s)	ATM (155 Mb/s)
Periapical (x 1)	300 Kb	1.4 min	42 s	1.6 s	0.02 s
Bitewings (x 4)	1.2 Kb	5.5 min	2.8 min	6.4 s	0.08 s
Panoramic	6 Mb	27 min	14 min	32 s	0.31 s

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*Transmission time depends on network infrastructure. (Transmission times extrapolated from data from Ruggiero C: Teleradiology: A review. J Telemed Telecare 4:25-35, 1998.)

POTS = Plain old telephone system; ATM = asynchronous transfer mode.

Electronic transfer of data files using the Internet is also achievable using transmission control protocol/ internet protocol (TCP /IP) over POTS lines. Although inexpensive and widely available, this technology is not time efficient, and transmission speeds are unpredictable.[17] One must remember not to confuse image quality with transmission speed. Information is not lost by using a telephone line; it just takes longer for the information to arrive.

To improve transmission speeds, many teleradiology systems apply data compression algorithms because compressed files can be transmitted in a shorter time (Table 2). Many commercial digital radiography systems compress image files for storage.[15]

Compression algorithms may be either reversible or irreversible. Reversible compression algorithms are referred to as *lossless*, and irreversible algorithms are referred to as *lossy*.

Lossless compression algorithms can achieve 1.5:1 to 3.0:1 data compression ratios with no loss of information. There are several advanced lossless compression algorithms in common use, including differential pulse-code modulation, hierarchical interpolation, difference pyramid, bit-plane encoding, and multiplicative autoregression. Higher compression ratios are necessary for a significant practical and economic impact on image transmission.[19]

Table 2: Effect of Compression on Digitized Transmission Time for a Panoramic Radiograph (6 Mb)

	Transmission Time*			
Compression Ratio	POTS Line (28.8 Kb/s)	POTS Line (56 Kb/s)	DS-1 Line (1.5 Mb/s)	ATM (155 Mb/s)
1:1	27 min	14 min	32 s	0.31 5
2:1	13.5 min	7 min	185	0.165
10:1	2.7 min	1.4 min	3.2 s	0.03 s
20:1	1.4 min	32 sec	1.6 s	0.02 s

Transmission time depends on network infrastructure.

POTS = plain old telephone system; ATM = asynchronous transfer mode; Kb / s = kilobyte per second; Mb / s = megabyte per second.

Compression ratios of 10:1 to 20:1 are achievable with lossy compression, which result in shorter transmission times. There is some controversy, however, as to the effect of lossy compression on the diagnostic quality of the image because it cannot be claimed that important information was not lost.[19]By definition, lossy algorithms irreversibly lose information.

Some have questioned the clinical significance of this loss when interpreting images.[19,20,21]The most widely used lossy algorithm is that defined by the Joint Photographic Expert Group (JPEG). Not originally intended for medical purposes, JPEG is hampered by block artifacts at higher compression ratios.[17] Extensions of JPEG, however, have improved its performance. There is currently an increased interest in wavelet transformation algorithms, which has the promise of achieving even higher compression ratios with no perceptible loss of diagnostic information.[22] Several other lossy algorithms are presently being studied for application to medical imaging. These compression protocols include two-dimensional discrete cosine transform, full-frame discrete cosine

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transform, lapped orthogonal transform, and sub-band coding as well as vector quantization, quad trees, and adaptive predictive coding.[17] Two studies evaluating chest radiographs have shown that lossy compression ratios of 20:1 can be applied without significant loss of interpretive quality. [19,20]

Interconnectibility Standards

By the late 1970s, it became apparent that a standardized method for transmitting images and associated information data between units of different manufacture was necessary. Proprietary formats made some interconnections difficult, if not impossible. In 1982, the ACR and the National Electrical Manufacturers' Association formed a joint committee to develop an industry standard. Version 1.0 was published in 1985, followed by two revisions in 1986 and 1988. A more inclusive version 2.0 was introduced in 1988. Version 3.0, known as *Digital Imaging and Communications in Medicine* (DICOM or DICOM-3) was released in 1993.[1,18,23] DICOM specifies interconnectibility standards that uniquely address not only image files, but also text files containing associated information that is necessary for optimal interpretation.[18]The standard contains three general domains: information modeling, technology, and communication

protocols. DICOM also specifies levels of conformity to the standard that clearly defines the nature of a manufacturer's claims to conformity. In 1993, Benn et al[23] reviewed the DICOM standard and found it to be readily adaptable for use in dentistry. Work is in progress on specific extensions of the DICOM standard for dental applications.

Legal and Ethical Issues

As is commonly the case with new technologies and applications of existing technologies, unique medical and ethical implications have arisen with the maturation of teleradiology. Although not new, these implications must be addressed in this new context. These issues include professional licensure, credentials and clinical privileges, liability, physician-patient relationships, and privacy and confidentiality. The ACR recognized these new dilemmas and addressed them as part of the ACR Standard for Teleradiology, which was released in 1984.[1]Not intended to be rules, these standards attempt to define principles of good radiology practice. Many of these issues have been addressed in at least a limited manner with respect to medicine; they have been only minimally addressed for dentistry. Nonetheless, the medical implications are assumed to be similar for dentistry.

Licensure

Teleradiology has the potential to facilitate the interstate practice of dentistry and medicine and confound conventional legislation. The inherent dilemma is that of a practitioner licensed in one state and interpreting or consulting on images made in another. As a result of the concept of state sovereignty under the U.S. Constitution, professional licensure regulatory legislation is disparate among the states. Each state retains the right to determine under what conditions they license practitioners."National licensure, although long successful in federal agencies (military, Public Health Service, Veterans' Affairs), does not appear to have significant political support. National licensure may create constitutional conflicts.[24]

Credentials and Clinical Privileges

Credentials and clinical practicing privileges, although not a major issue in private dental offices, must also be addressed in this new context. Academic and large clinical health care institutions have specific guidelines and rules that permit practice within that setting.[25] The ACR Standard on Teleradiology recommends that practitioners maintain credentials and be privileged at both the sending and the receiving sites.[1]

Professional Liability

Physicians involved in teleradiology may also be in a unique situation regarding professional liability. The two legal issues that are brought into question with long-distance care and consultations are that of the existence of physician-patient relationship and jurisdiction. The legal implications to these issues are complex and situational.[26]

The nature of the physician-patient relationship, within the broad context of telemedicine, centers on where the primary relationship resides-with the presenting practitioner or the consulting practitioner. As in any consultation scenario, the presenting practitioner typically has the primary relationship with the patient. In radiology, the patient may not

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meet personally with the radiologist, and the long-distance relationship may not differ significantly from that of the conventional one. The ACR recommends that each individual practitioner consult with his or her professional liability carrier in this regard. As always, the practitioner performing the radiographic interpretation is responsible for the quality of images being reviewed.[1] It has also been recommended that practitioners who engage in telemedicine (i.e., teleradiology) practice should 'assume that their long-distance encounters carry similar professional obligations to their non telemedicine relationships.[24,27]

To compel compliance with state practice acts, jurisdiction must be established over the licensed practitioner. When the teleradiology relationship transcends state boundaries, the question of jurisdiction becomes situational and may vary among the states. Should a practitioner routinely be involved in interstate teleradiology consultations, the practitioner should expect to be subject to the laws of both states.[27,28]

Privacy, Confidentiality, and Security

Protection of patient privacy is a significant topic in medico legal circles, especially when data are collected and stored in an electronic format. There is no consensus as to whether electronic data are more or less susceptible to unauthorized access than when data are in a paper format. It has been suggested that the privacy of electronic patient data be defined by three elements.[32] The first is confidentiality, which relates to inappropriate access by unauthorized individuals. The second is integrity, which assumes that the record is correct and accurate over time. The third element is availability, which allows easy access to those authorized to use it. These issues may be addressed by controlling access at sending and receiving sites, electronically auditing record access, and encryption of transmitted datay,[9] Some have voiced concern over the potential for fraudulent image alteration.[14,15] It may not be reasonable merely to assure that adequate safeguards are resident within any teleradiology system. .

REIMBURSEMENT ISSUES

For medical procedures, Medicare currently reimburses for some teleradiology services because these services do not typically require face-to-face interaction between the radiologist and the patient. Because Medicare is administered by each state, reimbursement policies are not consistent everywhere. Additionally, each health insurance company is free to set its own reimbursement guidelines. Teleradiology consultations have not been addressed at any length from a dental perspective. In the absence of any policy consensus, providers could be discouraged from implementing teleradiology networks with their attendant maintenance costs. If the services are not self-sustaining, their acceptance and success are marginal at best.[11]

Summary

The technology of digital imaging and mage transmission is here. Notwithstanding all the advancements that have been made in teleradiology, this technology remains in its adolescence with respect to medicine-and infancy with respect to dentistry. As with any new technology, acceptance is a function of time. Individual practitioners' comfort levels with computerization, digital imaging, and long-distance communication will invariably affect the scenario. The advantages of savings in terms of cost and time, coupled with an increased demand for tertiary health care in underserved urban and rural areas, will facilitate the acceptance of teleradiology. Rapid advances of the last decades have created an electronic society only dreamed about in 1970. These changes can be expected to continue at an ever-increasing rate, and dentists must prepare themselves to be in step with these innovations.

References

1. American College of Radiology (ACR): Standard for Teleradiology. American College of Radiology, 1994
2. Anonymous: Sending dental X-rays by telegraph. Dental Radiography and Photography 2:16, 1929
3. Farman AG, Farag AA: Teleradiology for dentistry. Dent Clin North Am 37:669-681, 1992
4. Gershon-Cohen J, Cooley A: Telegnosis. Radiology 55:582-587, 1950
5. Barrett JE, Brecht RM: Historical context of telemedicine. *In* Viegas SF, Dunn K (eds): Telemedicine-Practicing in the Information Age.Philadelphia, Lippincott-Raven, 1998, Pg: 9-16

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6. Murphy RL, Bird KT: Telediagnosis: A new community health resource: Observationson the feasibility of telediagnosis based on 1000 patient transactions. Am J Public Health 64:113-119, 1974
7. Brecht RM, Barrett JE: Telemedicine in the United States. *III* Viegas SF, Dunn K (eds): Telemedicine-Practicing in the Information Age. Philadelphia, Lippincott-Raven,1998, PI' 25-30.
8. Perednia DA, Allen A: Telemedicine technology and clinical applications. JAMA. 273:483-488, 1995.
9. Goldberg MA: Teleradiology and telemedicine. Radiol Clin North Am 34:647-665,1996
10. Franken EA Jr, Bergaum KS, Smith WL, et al: Teleradiology for rural hospitals:Analysis of a field study. J Telemed Telecare 1:202-208, 1995
11. Reid J: A Telemedicine Primer: Understanding the Issues. Billings, MT, Innovative Medical Communications, 1996
12. Dove SB, McDavid WD: Digital panoramic and extraoral imaging. Dent Clin North Am 37:541-551, 1993
13. Miles DA: Imaging using solid state detectors. Dent Clin North Am 37:531-540, 1993
14. Huda W, Rill LN, Benn DK, ct a1: Comparison of a photostimulable phosphor system with film for dental radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 83:725- 731, 1997
15. Alder ME: Intraoral digital radiography. Tex Dent J 112:31-35, 1995
16. Gayler B, Gitlin J, Rappaport W, et al: Teleradiology: An evaluation of a microcom-puter- based system. Radiology 140:355-360, 1981
17. Ducon le Pointe H: Teleradiology. Biomed Pharmacother 52:64-68, 1998
18. Esch O: Diagnostic and support services in the telemedicine environment: Radiology and clinical imaging. *In Viegas* SF, Dunn K (eds): Telemedicine-Practicing in the Information Age. Philadelphia, Lippincott-Raven, 1998, Pg: 193-198
19. MacMahon H, Doi K, Sanada S, et al: Data compression: Effect on diagnostic accuracy in digital chest radiography. RadioJogyI78:175-179, 1991.
20. Aberele DR, Gleeson P, Sayre JW, et al: The effect of irreversible image compression on diagnostic accuracy in thoracic imaging. Invest Radiol 28:398-403, 1993.
21. Martel JJ, Martin-Santos FJ, Lopez-Alonso A: Accuracy of teleradiology in skeletal disorders: Solitary bone lesions and fractures. J Telemed Telecare 1:13-18, 1995
22. Avrin DE, Andriole KP: The future of teleradiology in medicine. West J Med 169:286, 1998
23. Benn DK, Bidgood WD, Pettigrew JC: An imaging standard for dentistry: Extension of the radiology DICOM standard. Oral Surg Oral Med Oral Pathol 76:262-265, 1993.
24. Blair RD, Bambas A, Stone TH: Legal and ethical issues. *III* Viegas SF, Dunn K (eds): Telemedicine-Practicing in the Information Age. Philadelphia, Lippincott-Raven, 1998, Pg: 49-59
25. Coons T: Teleradiology: The practice of radiology enters cyberspace. Radiol Technol 67:125-140, 1995
26. Ad Hoc Committee on Telemedicine: Federation of State Medical Boards: A Model Act to Regulate the Practice of Medicine Across State Lines: An Introduction and Rationale.Federation of State Medical Boards, 1996
27. Dure-Smith P, Fymat AL: Teleradiology: Will it transform the practice of radiology? Radiology 203:49A-50A, 1997
28. Berlin L: Malpractice issues in radiology - teleradiology. AJR Am J Roentgenol 170:1417-1422, 1998