Telemedicine in wound healing

Sophie M Jones, Paul E Banwell, Peter G Shakespeare

Jones SM, Banwell PE, Shakespeare PG. Telemedicine in wound healing. Int Wound J 2004;1:225–230.

ABSTRACT

Better care for patients and improved health care depends on the availability of good information which is accessible when and where it is needed. The development of technology, more specifically the Internet, has expanded the means whereby information can be acquired and transmitted over large distances enabling the concept of telemedicine to become a reality. Telemedicine, defined as the practise of medicine at a distance, encompasses diagnosis, education and treatment. It is a technology that many thought would expand rapidly and change the face of medicine. However, this has not happened and during the last decade although certain telemedicine applications, such as video-consulting and teleradiology, have matured to become essential health care services in some countries, others, such as telepathology, remain the subject of intensive research effort. Telemedicine can be used in almost any medical speciality although the specialities best suited are those with a high visual component. Wound healing and wound management is thus a prime candidate for telemedicine. Development of a suitable telemedical system in this field could have a significant effect on wound care in the community, tertiary referral patterns and hospital admission rates.

Key words: Telemedicine • Wound healing

INTRODUCTION

Telemedicine, defined as the practise of medicine from a distance, is not a new concept. Medical consultations have been taking place over the phone probably since its invention in 1876. The first exchange of physiological data occurred in the 1960s with monitoring of astronauts in space by National Aeronautics and Space Administration. However, the subsequent growth of the Internet has provided a unique opportunity for rapid, global clinical communication. Nowadays, complex data can be exchanged over large distances in a matter of seconds, enabling access to information like never before.

Telemedicine in simple terms involves the transfer of medical information from one computer to another. This often involves still images but may include video, X-rays or other patient data. This transfer of information can enable faster interaction between clinicians and act as a communication tool between clinicians as seen in general surgical videoconferencing outpatient clinics (1).

In the past, the technology required for this was expensive and complicated which limited the growth and development of this type of medical communication. There were also concerns over confidentiality of exchanged data, which slowed development. However, costs are decreasing everyday and technology improving producing cheaper, faster and more secure transfer of data. As a result, worldwide use is slowly increasing and today over 250 000 telemedicine consultations are generated annually by many different specialities.

Specialities that benefit most from telemedicine are those with a high visual component such as histopathology, radiology and

Key Points

- telemedicine is the practice of medicine from a distance
- today this is the transfer of medical information from one computer to another
- growth of such technology has been limited by cost
- with decreasing costs and technology improvements, telemedicine is becoming more accessible

Authors: SM Jones, MRCS, Odstock Burns, Wound Healing & Reconstructive Surgery Charitable Trust, Laing Laboratory, Salisbury District Hospital, Salisbury, Wiltshire SP2 8BJ, UK; PE Banwell BSc FRCS, Odstock Burns, Wound Healing & Reconstructive Surgery Charitable Trust, Laing Laboratory, Salisbury District Hospital, Salisbury, Wiltshire SP2 8BJ, UK; PG Shakespeare PhD, Odstock Burns, Wound Healing & Reconstructive Surgery Charitable Trust, Laing Laboratory, Salisbury District Hospital, Salisbury, Wiltshire SP2 8BJ, UK
Address for correspondence: PE Banwell, Odstock Burns, Wound Healing & Reconstructive Surgery Charitable Trust, Laing Laboratory, Salisbury District Hospital, Salisbury, Wiltshire SP2 8BJ, UK
E-mail: paul@paulbanwell.co.uk

Key Points

- patients benefiting most are those required to travel extensive distances to see appropriate clinicians
- wound care lends itself to telemedicine
- telemedicine can bring wound care expertise to the patient's bedside, preventing travelling and unnecessary discomfort
- telemedicine can also be used as a teaching tool
- telemedicine requires high speed internet access to transmit large, high quality images quickly

dermatology. Patients who benefit most from telemedicine are those who find reaching clinicians difficult whether due to difficulty in travelling or distances. Wound healing is a branch of clinical practice that is visually based and, in many cases, managed in a community-setting. These patients are thus distanced from specialists and the wounds may make travel difficult. It is therefore likely that transmission of individual wound information to the General Practitioner (GP) surgery or a specialist centre would be of value to the GP or district nurses treating difficult and recalcitrant wounds in the community. As such, wound healing makes an ideal area for the development of telemedicine.

WOUND-HEALING MANAGEMENT

Chronic wounds constitute a debilitating health care problem with significant clinical and social implications. Studies have shown that consistent, skilled care is the key to healing chronic wounds, but this is expensive and typically unavailable. The current principal goals of wound management are therefore to provide effective care whilst containing costs.

It is more cost effective to bring the patient to the clinician in the form of outpatient clinics, but this can be difficult in wound healing as many of these patients find travel awkward or be house bound and may require hospital transport or other help to attend. A cost-effective method of bringing the patient to the clinician could involve the use of telemedicine. A clinic revolved around images of patient's wounds would enable the clinician to review more wounds during a single clinic without travel involved by either party. It would prevent uncomfortable and difficult travel arrangements for patients whilst enabling their wounds to be reviewed regularly by an expert in the field. The images also provide a useful record of the wound-healing progression. Several studies have shown that the accuracy of a digital imagery for chronic wounds (2,3) is high enough to enable accurate decision making. 'Virtual clinics' where a number of community patients can be reviewed by a single consultant without a face-to-face consultation could therefore save considerable time and transport costs for the Trust.

For example, in 'hub and spoke' specialities such as plastic surgery, one tertiary centre may serve several hospitals within a region. Currently, consultants in these specialities may spend a significant proportion of their time travelling to and from peripheral hospitals to review outlying patients or attend clinics. The creation of foundation hospitals in the United Kingdom (UK) will exacerbate this problem with patients being located farther from their Specialist Clinicians than before. Telemedical systems could represent one method of extending the arm of clinical expertise into the community. Furthermore, such a system may provide an ideal vehicle for wound care specialists to consult and discuss patient management within a tertiary/quaternary super highway.

Telemedicine can also be used as a teaching tool with which to increase community knowledge base as well as providing support network to allied professionals in the community, e.g. district nurses. With patient knowledge and expectations increasing, this would enable an increased level of specialist care to be available where it is needed.

One of the keys to making telemedicine efficient and cost effective in this area is to use it as a remote diagnostic and treatment tool. Patients can be cared for in a variety of sites outside the hospital setting by transmitting high-resolution images to specialists at multiple locations that can be reviewed simultaneously at a convenient time.

COMPONENTS OF A TELEMEDICINE SYSTEM

Telemedicine involves a collection of technologies including computers, communication networks and specialised medical equipment. The most common feature of a telemedicine system is the ability to transmit high-quality digital medical images across a communication line. The advantage of digital signals is that they can be transmitted through a digital communication channel irrespective of the source of the signal; hence, digitised video, X-rays, etc. may be sent through the same communication channel.

A telemedicine system requires remote connections, usually through Integrated Services Digital Network (ISDN) or ASDN lines which have bandwidths large enough to handle the amounts of data being transferred. Still images, video and/or audio data are provided using a digital recorder.

TELEMEDICINE TYPES

Telemedicine can be divided into different categories according to the time scale and type of interaction involved. Most commonly, however, it is split into two types: 'real-time' or 'store-and-forward'. Real-time telemedicine involves the transfer of images that are viewed synchronously in dedicated transmission rooms. Examples of this can be found in 'videoconferencing' or 'telepsychiatry', which rely on instantaneous interactions. This type of telemedicine requires the presence of all parties at the same time. However, real-time technology can be expensive to install and maintain. Quality of acquired data can be variable and the software complex thus requiring a certain level of technical competency.

Store-and-forward systems (Figure 1), however, rely on 'time-independent' communication. This type of telemedicine usually involves still images, although not exclusively, and has been used to great effect by the military (4) and dermatology services (5,6). Store-and-forward systems are generally cheaper to install and maintain. The software is also simpler to use. All these factors have made store-and-forward systems more common currently.

IMAGES

A digital image is stored as a matrix of pixels (picture elements). The majority of computer screens display at least 640×480 pixels. The amount of memory required to store an image varies considerably depending on the source of the image. Thus, a digital X-ray is usually approximately 2000×2000×12 pixels (i.e. 12 bits per pixel with an area of 200 pixels squared) which is equivalent to storage of about six megabytes (Mb). In contrast, a single CT slice requires 512×512×12 pixels or about 400 kilobytes (Kb). Colour images require greater number of bits, approximately 24 bits per pixel, to represent smooth colour transitions. However, the majority of clinical images or histopathology images can have resolution close to television resolution (800×600×24, requiring almost 1·5 Mb per image) for most purposes.

Video images of the patient can be acquired for assessment. The human eye is less perceptive to detail in moving images; hence, video images tend to be around 300×200 pixels in size with a pixel depth of 16 bits for colour. Although 25–30 images or frames per second is the speed at which televisions work, lower rates of around 15 frames per second are sometimes adequate. However, frame rates set below 10–15 are noticeably jumpy. The data rate for video information is enormous. A 300×300×16 still image requires about 120 Kb, but at a video rate of 15 frames per second, the data transmission rate required is 1·8 Mb per second. Therefore, compression of data is essential in order.

Lim (2001) routinely selected a medium resolution setting on the digital camera (1152×768 pixels), as there is now convincing theoretical and clinical evidence defining the threshold of visual perception as 768×512 pixels at optimum viewing distance (7). However, using higher resolutions (e.g. 1536×1024 pixels) can offer greater onscreen magnification without loss of sharpness.

IMAGE COMPRESSION

It is impractical to send large files over the Internet; therefore, compression software is used to reduce the storage size of the image or video data. There are two general types of image compression: 'Lossy' and 'Lossless'. Lossless compression guarantees that the process of compressing and decompressing an image will not change the image in any way. However, it can only compress images by 2:1. Much better rates of compression can be achieved by using Lossy compression.

Lossy compression techniques achieve higher rates of compression by discarding some of the information in the image. By taking advantage of the fact that the human eye perceives small colour changes less accurately

Figure 1. Telemedicine desktop system.

Key Points

- telemedicine can be divided into two distinct types
- real time where images are transferred synchronously
- store-and-forward which is time-independent with images being transferred at a later date
- images can be digital images both still and video
- image compression helps with the transfer

Key Points

- to be effective the process needs to demonstrate acceptable levels of accuracy and reliability
- cost effectiveness of such systems has only been demonstrated for the military or prison populations
- security through encryption is imperative
- confidentiality and security are probably the most contentious issues

than small changes in brightness. Lossy systems remove small differences in pixel colour. The most commonly used Lossy compression technique is the Joint Photographic Expert Group (JPEG) image compression mechanism. This technique compresses the whole image (Figure 2) using the same compression factor, regardless of regions of interest, although there are some variations on this program especially in the field of radiology (e.g. DICOM).

Video is also amenable to Lossy compression, as the eye does not have time to detect imperfections on a single frame. The largest gains for video compression derive from a technique known as frame differencing. Frame differencing calculates what parts of the image have changed between two frames and only transmits the differences instead of the whole frame.

ACCURACY AND RELIABILITY

Clinicians are accustomed to making decisions with relatively incomplete information. Relative to face-to-face consultations, there is a reduction in available information with telemedicine systems. To be effective and safe, the process needs to demonstrate acceptable levels of accuracy and reliability. Accuracy is reflected by the degree of concordance between the telemedical and face-to-face diagnoses. Reliability is dependent on how consistently a set of results is reproduced with different operators. Diagnostic accuracy and reliability of real-time telemedicine compared with face-to-face consultations is between 59% and 80% in the literature (8). These findings are similar for store-and-forward methods giving diagnostic agreement between 59% and 93% in various studies (9–14).

Figure 2. Typical compressed image.

The effect of Lossy compression on the accuracy of clinical diagnoses has also been studied. Compression rates around 10 : 1 (15) up to 20 : 1 (16) were found not to change the detection of abnormalities in thoracic X-rays, CT scans or hand X-rays (17). There is some evidence that Lossy compression methods in telemedicine may not adversely affect diagnostic accuracy of images for ultrasonography (18), histopathology (19), dermatology (20) or plastic surgery (21).

COST EFFECTIVENESS

In the past, telemedicine systems were expensive and built specifically for a hospital and chosen remote site. Nowadays, there are numerous telemedicine hardware packages available (e.g. Mediview, Telemarque, DISTAR). Each system varies in exact specifications, but the basic components are similar.

Cost effectiveness has only been clearly demonstrated for the military and in prison populations (22), as the owners of the system receive the benefit of decreased travel expenses. However, evidence for direct cost savings to the users of telemedicine elsewhere is poor (23), even when the distances concerned are large.

SECURITY

Using either anonymous data, such as in the British Army, or encryption techniques can protect confidential Patient Information. Anonymous data is inappropriate for networks with high volumes of similar referrals. The use of the National Health Service (NHS) network is thought to be the best medium for the transfer of clinical information according to the Information for Health strategy (24). The use of this NHS-specific network has reduced the need for data encryption although it is acknowledged that no system is entirely safe.

Security and confidentiality are probably the most contentious issues haunting the process of modernising the NHS using information technologies (ITs) even though many of the issues raised are similar to those involving paper records.

MEDICOLEGAL ISSUES

The emergence of telemedicine as a technique for health services raises many issues. Clinicians and managers realise that with new customs and practices come new dangers. Areas of concern identified include patient consent, the creation of the electronic record, transmission, physical risk, professional indemnity and litigation, ISDN security, the NHS network and encryption. Many of these concerns are mirrored from those of paper records. It is the aim of the Information for Health strategy (24) to ensure that technology is brought into the NHS to ensure information is available to help patients receive the best possible care through the use of IT. Indeed, the introduction of telemedicine is a high priority in current governmental legistration.

DISCUSSION

Fundamentally, telemedicine is about people and their health needs, rather than technology and its development; hence, human and organisational factors are likely to be the main determinants of how successful a telemedicine project can be. Research has identified factors that are crucial to the success of a telemedicine programme. These include: a) the need to promote its potential and actual benefits across all cultures, irrespective of systems, b) and the need to address and harmonise legal and regulatory issues between and within countries and health care systems.

Web-based medicine has enabled surgeons in developing regions of the world to gain direct access to recognised experts and has been used with great success in Australia and the United States of America where the distances travelled by patients is large. Distances are not such an issue in the UK, which perhaps partly explains why telemedicine development has been slower. The UK national telemedicine database has 234 programmes listed currently, although only a minority have moved into routine or mainstream use.

The National Programme for IT in the NHS announced in 2002 focuses on key developments to improve the patient experience and the delivery of care and services. There are four key areas: electronic appointment booking, an integrated care records service, electronic prescribing and underpinning the IT infrastructure with sufficient connectivity and broadband capacity to support the critical national applications and local systems. The National Programme has been created specifically to manage the introduction of new NHS-wide applications and services. Central funding for the National Programme for IT in the NHS will be £370 million in 2003/04, £730 million in 2004/05 and £1·2 billion in 2005/06. This represents investment of £2·3 billion in IT for the NHS over the next 3 years and supports the vision of the NHS plan.

Telemedicine like all of medicine is an ever-changing and evolving discipline, and information on its costs and benefits are becoming of increasing interest to decision makers in health care. Thus, wound management projects which use telemedicine have shown potential for their role in evaluating remote patients. These projects show promise for potential improvement in the quality of wound care, enhancing availability, reducing costs and generating valuable outcome data.

REFERENCES

1 Wallace P, Haines A, Harrison R, Barber J, Thompson S, Jacklin P *et al.* Joint teleconsultations (virtual outreach) versus standard outpatient appointments for patients referred by their general practitioner for a specialist opinion: a randomised trial. Lancet 2002;359(9322):1961–8.

2 Gardner SE, Frantz RA, Specht JK, Johnson-Mekota JL, Buresh KA, Wakefield B *et al.* How accurate are chronic wound assessments using interactive video technology? J Gerontol Nurs 2001;27(1):15–20.

3 Kim HM, Lowery JC, Hamill JB, Wilkins EG. Accuracy of a web-based system for monitoring chronic wounds. Telemed J E Health 2003;9(2):129–40.

4 Vassallo DJ. Twelve months' experience with telemedicine for the British armed forces. J Telemed Telecare 1999;5 (Suppl. 1):S117–S118.

5 Van den Akker Th. Teledermatology as a tool for communication between general practitioners and dermatologists. J Telemed Telecare 2001;7(4):193–8.

6 Weinstein R. Patient and referring provider satisfaction with teledermatology. J Am Acad Dermatol 2002;747(1):68–72.

7 Bittorf A, Fartasch M, Schuler G, Diepgen TL. Resolution requirements for digital images in dermatology. J Am Acad Dermatol 1997;37:195–8.

8 Gilmour E, Campbell SM, Loane MA, Esmail A, Griffiths CE, Roland MO *et al.* Comparison of teleconsultations and face-to-face consultations: preliminary results of a United Kingdom multicentre teledermatology study. Br J Dermatol 1998;139(1):81–7.

9 Buntic RF, Siko PP, Buncke GM, Ruebeck D, Kind GM, Buncke HJ. Using the Internet for rapid exchange of photographs and X-ray images to evaluate potential extremity replantation candidates. J Trauma 1997;43(2):342–4.

10 Roa L, Gomez-Cia T, Acha B, Serrano C. Digital imaging in remote diagnosis of burns. Burns 1999;25(7):617–23.

11 Roth AC, Reid JC, Puckett CL. Digital images in the diagnosis of wound healing problems. Plast Reconstr Surg 1999;103:483.

Key Points

- telemedicine is about people and their health needs
- some fundamental issues need to be addressed to ensure propagation of telemedicine
- acceptance and proliferation of telemedicine is different in varying geographical regions
- the National Health Service in the UK is investing £2·3 billion to improve its information technology over the next 3 years

12 Tachakra S. Level of diagnostic confidence, accuracy, and reasons for mistakes in teleradiology for minor injuries. Telemed J E Health 2002;8(1):111–21.
13 Tachakra S, Lynch M, Newson R, Stinson A, Sivakumar A, Hayes J *et al.* A comparison of telemedicine with face-to-face consultations for trauma management. J Telemed Telecare 2000;6 (Suppl. 1): S178–S181.
14 O'Reilly S, Spedding R, Dearden C, Loane M. Can x rays be accurately interpreted using a low cost telemedicine system? J Accid Emerg Med 1998;15(5):312–4.
15 Cosman PC, Davidson HC, Bergin CJ, Tseng CW, Moses LE, Riskin EA *et al.* Thoracic CT images: effect of lossy image compression on diagnostic accuracy. Radiology 1994;190(2):517–24.
16 Aberle DR, Gleeson F, Sayre JW, Brown K, Batra P, Young DA *et al.* The effect of irreversible image compression on diagnostic accuracy in thoracic imaging. Invest Radiol 1993;28(5):398–403.
17 Sayre JW, Ho BK, Boechat MI, Hall TR, Huang HK. Subperiosteal resorption: effect of full-frame image compression of hand radiographs on diagnostic accuracy. Radiology 1992;185(2):599–603.
18 Beard DV, Hemminger BM, Keefe B, Mittelstaedt C, Pisano ED, Lee JK. Real-time radiologist review of remote ultrasound using low-cost video and voice. Invest Radiol 1993;28(8):732–4.
19 Weinstein RS. Telepathology: practicing pathology in two places at once. Clin Lab Manage Rev 1992;6(2):171–3.
20 Perednia DA, Gaines JA, Rossum AC. Variability in physician assessment of lesions in cutaneous images and its implications for skin screening and computer-assisted diagnosis. Arch Dermatol 1992; 128(3):357–64.
21 Pap S. Telemedicine in plastic surgery: e-consult attending surgeon. Plast Reconstr Surg 2002;110(2): 452–6.
22 Hammack GG. Telemedicine in corrections. Curr Probl Dermatol 2003;32:148–52.
23 Whitten PS, Mair FS, Haycox A, May CR, Williams TL, Hellmich S. Systematic review of cost effectiveness studies of telemedicine interventions. BMJ 2002; 324(7351):1434–7.
24 Department of Health. An information strategy for the modern NHS 1998–2005. UK: Information for Health, 1998.

