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Original article

Telemedicine in acute plastic surgical trauma and burns

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***Background*: Telemedicine is a relatively new development within the UK, but is increasingly useful in many areas of medicine including plastic surgery. Plastic surgery centres often work on a hub-and-spoke basis with many district hospitals referring to one tertiary centre. The Queen Victoria Hospital is one such centre receiving calls from more than 28 hospitals in the Southeast of England resulting in approximately 20 referrals a day.**

***Objective*: A telemedicine system was developed to improve trauma management. This study was designed to establish whether digital images were sufficiently accurate enough to aid decision-making. A store-and-forward telemedicine system was devised and the images of 150 trauma referrals evaluated in terms of injury severity and operative priority by each member of the plastic surgical team.**

***Results*: Correlation scores for assessed images were high. Accuracy of 'transmitted image' in comparison to injury on examination scored > 97%. Operative priority scores tended to be higher than injury severity.**

***Conclusions*: Telemedicine is an accurate method by which to transfer information on plastic surgical trauma including burns.**

Key words: Telemedicine – Store-and-forward – Trauma management

Telemedicine is a relatively new development within the UK, but is increasingly useful in many areas of medicine including plastic surgery.[1,2] It is widely felt that telemedicine has the potential to improve patient care within health care systems through cost saving and time efficiency in patient care.[3] It is already being used with great success in many hospitals in the US and Australia as well as the military service within the UK.[4]

Definition

Telemedicine is the assessment and review of patient information (history, examination or investigations) by health professionals who are separated temporally and/or spatially from their patients (*i.e.* the practise of medicine from a distance). This interaction is most usually between clinicians but can involve direct clinician–patient contact (*e.g.* telepsychiatry).[5]

There are several types classified according to the type of interaction and the information transmitted. Usually, it is divided into two main areas – real-time and store-and-forward. Real-time telemedicine is used in video-conferencing and involves synchronous interaction between doctor and patient. Store-and-forward telemedicine involves prior 'storage' of either video or still images, which are then sent to the clinician. This may be at a later time or date. Examples of store-and-forward applications are tele-dermatology and teleradiology.

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At the Queen Victoria Hospital (QVH), injured patients are accepted from 15 different NHS trusts (more than 28 hospitals) from all over the Southeast of England. This is a large area and patients often travel for more than 2 h for a plastic surgical consultation. With this in mind, we wanted to find out whether or not a telemedicine system would be viable and useful in our practice. Our objective was to use it to expedite and support the clinical decision-making process particularly with regard to accurate initial assessment and treatment prioritisation.

Equipment

Successful telemedicine requires the means to capture images and access to a telecommunications network. Our hospital had previously installed several ISDN lines and was a part of the NHSnet (a National Health Service based intranet network). Digital cameras were provided in the emergency departments of our referring hospital network. Our IT staff developed image-handling software suitable to our requirements that would enable encryption of the

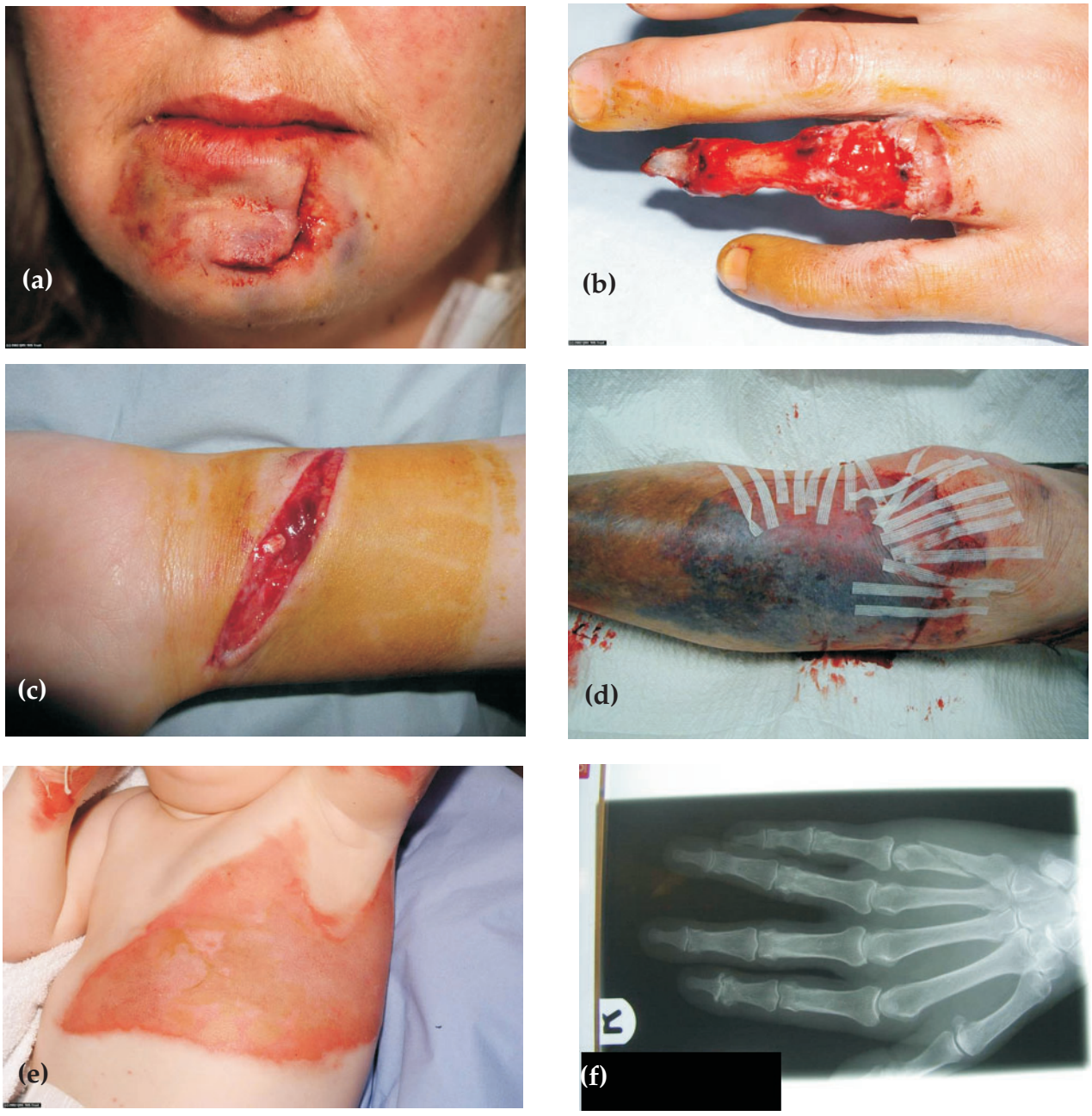

Figure 1 Examples of the quality of JPEG images in use with this system. (A) Facial laceration; (B) degloving injury to ring finger; (C) wrist laceration; (D) pretibial laceration; (E) scald; (F) X-ray showing fracture of the 5th metacarpel.

Table 1 Scoring system used by authors to grade the severity of injury and its operative priority

	Grade of injury		Operative priority
1	Skin only, nailbed injuries	1	Chronic (out-patients)
2	Closed fractures, nerves, extensor tendons	2	Soon (< 48 h)
3	Flexor tendons, open fractures	3	Very soon (< 24 h)
4	Poor vascularity	4	Urgent (< 6 h)
5	Devascularised, resuscitation burns	5	Immediate

images prior to transfer over the NHSnet. Our IT and photographic staff co-ordinated an educational programme for all personnel likely to be involved in image capture and transfer for the purposes of telemedicine.

Image resolution can be expressed in terms of pixels. The higher the image resolution, the better the fidelity or accuracy of the image. A pixel is a picture element, the smallest unit of the display and is expressed as the number of dots of light on the screen. Slide photography provides a resolution equivalent to 4000 x 6000 pixels. A study comparing different resolutions found 800 x 600 pixels to be adequate for dermatological diagnosis.[6] This still requires large image files to be sent over the Internet and, therefore, these images need to be compressed into smaller, more practical files for transit. Thus compression software was used with images in JPEG (Joint Photographic Expert Group) format at 800 x 600 pixels for this study.

Methods

The referring clinician attained consent for the acquisition of digital photographs from each patient. In all, 150 of these digital images were e-mailed to the QVH via NHS intranet by the referring clinicians who also made a conventional telephone referral (Fig. 1). Confidentiality was maintained, as images that would identify the patient were not included. Each injury history gathered from the telephone referral was recorded and made available during image assessment. The received images were assessed and ranked at the QVH in terms of injury severity and operative priority by the trauma team on a scale devised by the authors (Table 1). On arrival of the patient at the minor injuries unit at the QVH, the injury was re-assessed using the same criteria. Scores were then compared.

Table 2 Types of injuries referred using telemedicine

Type of injury	Total
Burn	15
Flexor tendon	9
Skin only	8
Nerve	7
Open fracture	9
Nailbed injury	8
Extensor tendon	9
Bite	5
Replant/revascularisation	6
Facial injury	5
Closed fracture	1
Total	82

Table 3 Range of injury severity and operative priority of referred images according to scoring system

	1	2	3	4	5	Total
Injury severity	21	17	27	10	7	82
Operative priority	14	24	21	16	7	82

Results

In all, 150 images were received (Table 2), of which 20 were deemed inadequate. Only 82 of the remaining images were subsequently entered into the study due to losses from data gathering. Scores for each image and corresponding patient examination were compared and this was repeated for all members of the surgical team (Table 3). It was demonstrated that all surgeons had closely matched scores for both grade of injury and for operative priority (Table 4). Correlation coefficients were calculated for the data and a higher value indicated closer matching of the assessment made from the telemedicine image and the patient examination. The highest

Table 4 Mean results of prioritisation and severity of injury from image only and on examination

	SHO		Registrar		Consultant	
	Grade	Priority	Grade	Priority	Grade	Priority
Image	2.48 (± 1.08)	2.58 (± 1.70)	2.68 (± 1.01)	2.68 (± 1.13)	2.36 (± 0.81)	2.73 (± 1.10)
Examination	2.59 (± 0.99)	2.60 (± 1.09)	2.58 (± 0.98)	2.59 (± 1.15)	2.27 (± 0.90)	2.55 (± 1.13)

Table 5 Correlation coefficient of the results

		Correlation coefficient
SHO	Grade	0.81
	Priority	0.87
Registrar	Grade	0.78
	Priority	0.89
Consultant	Grade	0.81
	Priority	0.93

correlation was seen in scoring the operative priority of patient injuries (Table 5). Overall, consultants achieved the highest correlation coefficients when compared to the more junior members of the team.

Discussion

The results show that injury assessment is similar whether using transmitted digital televisual image or patient examination. This suggests that transmitted digital images viewed on a monitor screen are an accurate form of transferring data. The calculated correlation coefficients revealed a high correlation in operative priority of patient injuries (Table 3). This is important since prioritisation of treatment will allow efficient decisions regarding subsequent management and transfer.

Grading of the injury was less accurate when values were compared. It appears it is more difficult to assess the grade of injury accurately from the image. It is felt that this is both less important than operative priority and also that skills tend to improve with use of the system.

This study demonstrates both the advantages and difficulties encountered in setting up a telemedicine system. Telemedicine is now an appreciated, established and well-used tool at the Queen Victoria Hospital and its referring hospitals. Images can be accessed from within the hospital from any computer terminal allowing senior input to be obtained for immediate advice on management, even whilst scrubbed in theatre. The system has been of particular benefit in the assessment of serious injuries. For example, an immediate decision can be made regarding a potential replant, which has obvious benefits not only for the patient but also in reducing emergency transfers and theatres being put on 'hold'' unnecessarily. Larger percentage burns are also difficult to assess in units with less experience and telemedicine provides a more accurate assessment of the size and depth of such wounds that may affect initial management decisions.

There are, however, disadvantages to telemedicine. The pictures are seldom perfect and must be evaluated in conjunction with an accurate history. New software had to be developed in order to ensure patient confidentiality of the transmitted images and adequate storage of data once received. Staff in all involved hospitals required training and retraining in order to use the equipment effectively. Resistance was experienced to the introduction of new technology into the established system of telephone referral. Technical difficulties encountered are recurrent and require constant maintenance to prevent system breakdown that is both discouraging to an already hard-pressed staff and can lead to skill loss. Capital outlay was significant (£70,000 for installation of computer network lines, equipment and software) and training of staff and system maintenance is on-going.

Conclusions

Telemedicine is an accurate method by which to transfer information. The system allows immediate transfer of injury information from a referring hospital to a remote specialist, tertiary centre. The images can be used to support and expedite clinical decision making without reliance on descriptions given over the phone. The added information gained from such images may help reduce the incidence of inappropriate referrals, unnecessary transfer of patients over large distances and improve patient care.

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