The specialty of plastic surgery has ancient roots, having evolved from military surgery and the requirement to reconstruct damaged limbs and correct deformities caused by injuries in battle. British military surgeons have made significant contributions to the progress of the discipline, with Sir Harold Gillies being perhaps the best known by the plastic surgery fraternity.1

Today’s British Defence Medical Services (DMS) are deployed world-wide, on sea and on land, in support of British Forces on operational, peacekeeping and humanitarian deployment. They also have a peace-time role in Germany and the UK, where the main triservice hospital is the Royal Hospital Haslar, Gosport, near Portsmouth. The Plastic Surgery Unit at Haslar is responsible for the provision of plastic surgery and burns care for services personnel wherever they may be deployed. There are currently only two consultant plastic surgeons in the DMS. The challenge of providing real-time specialist support to all locations where their expertise may be required is now being addressed by the recent introduction of telemedicine.

Telemedicine is the process whereby expert medical advice is provided through the use of communications technology. Depending on the needs of the user and the system chosen, telemedicine can include the use of electronic mail (e-mail), the Internet and the transmission of digitised still or video images, through to full online real-time video-teleconferencing.

In September 1997, the British Defence Medical Services decided to introduce their first telemedicine system to link the British military field hospital in Sipovo, Bosnia, to the Royal Hospital Haslar. The aim was to provide access to specialist consultation for personnel on operational deployment in support of the NATO peacekeeping mission set up after the Dayton peace accord of December 1995. A secondary consideration was to prevent unnecessary and expensive aeromedical evacuation of personnel back to the UK. The consultant staff at the field hospital in Sipovo consists of one general surgeon, one orthopaedic surgeon, a physician and two anaesthetists. The surgeons have no formal training in plastic surgery, although they have a broad general training.

The United States military medical services have been developing and using telemedicine systems in support of their forces for several years.2,3 Unfortunately, their use of expensive and complex technology, with the emphasis on live video-teleconferencing links, has created the false impression that telemedicine is perforce complicated and costly.

The planned British telemedicine link had the same aim as the American, but its design was kept much simpler, relying only on the transmission of still images attached to e-mails containing clinical information. A newly introduced high-resolution digital camera, a laptop computer and a satellite telephone were procured for the field hospital in Sipovo. Land lines would also be used if possible, but these could not be relied upon after years of war. At Haslar, the main requirements were a high-resolution monitor and a desktop computer for the newly established Telemedicine Unit, which would coordinate specialist opinions through its e-mail address at the radiology department (xray_haslar@compuserve.com). The system was set up in Sipovo by the second author, a general surgeon, following his deployment there in January 1998.

Initial plastic surgery experience with the first telemedicine links for the British Forces

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SUMMARY. In January 1998, the first telemedicine link for the British Defence Medical Services was established between the British military hospital in Sipovo, Bosnia and the Royal Hospital Haslar, the main triservice hospital in the UK. Further links were established later in the year. These simple links use a high-resolution digital camera, the Olympus C1400L and the C1400XL, to capture still images. These are then transmitted without loss of definition as electronic mail attachments to obtain specialist opinions in plastic surgery as well as in radiology, dermatology, orthopaedics, urology, ophthalmology, general medicine, maxillofacial surgery and pathology. Its use is illustrated by representative case reports from the first 11 referrals from Sipovo and elsewhere to the Plastic Surgery Department at Haslar. This system is suitable for use within both a military and a civilian context, anywhere in the world. It can readily be adapted for use by general practitioners and hospital doctors to facilitate referrals to plastic surgery departments.

Keywords: plastic surgery, burns, telemedicine.
Materials and Methods

The digital camera

To be suitable for telemedicine purposes, a digital camera has to reproduce images at sufficiently high resolution for a specialist clinician to give a confident second opinion on the image and clinical details alone. The camera chosen was the Olympus C1400L, as it featured the highest resolution among digital cameras available in 1997–1998 below the £6000 bracket. This model was introduced into the UK in November 1997 at a price of £1300. It has a resolution of 1280 × 1024 pixels (a total per image of 1,410,000 pixels). An Olympus 6-volt ac adaptor was obtained to power the camera. Two close-up filters (+3 and +4 dioptres magnification) and a macro lens (+10 dioptres) were obtained for use on eye or skin lesions.

Laptop computer

This consisted of a Rock Mentor 620, with a 13.3 inch TFT screen, Intel Pentium 200MMX microprocessor, 48 Mb RAM, 2.1 Gb hard drive and Windows 95 software.

The satellite telephone

This was a Saturn Bt transportable Inmarsat-B terminal with detachable antenna (Nera Ltd, Croydon, UK). The Saturn Bt transmitted data from Sipovo at a speed of 9.6 kbps, though it was also capable of a high-speed data service allowing a 56/64 kbps full duplex or simplex link with an ISDN network.

Communications and image manipulation software

Internet service provider

A subscription allowing unlimited use was taken out for Hospital Squadron Sipovo with America Online (AOL).

Olympus C95 software

This basic image manipulation software is supplied with the Olympus C1400L and is used to import, display, crop, compress and store images. No other software was required for image manipulation at Sipovo.

Software at Haslar

The Telemedicine Unit now uses readily available free software (Linux/GNU) for e-mail management and for further image manipulation if necessary. Commercially available software can be used instead. For instance, the second author uses AOL, Olympus C95 software and Adobe PhotoShop 5.0 on the backup laptop for the Telemedicine Unit.

Image transmission

For clinical images the camera is usually used on a tripod, utilising macro mode for close-ups. For radiographs, the camera is used in self-timer mode, on a tripod, in a darkened room, with the radiographs illuminated by a viewing box, at a distance of about 30 cm from the camera. The images are then downloaded onto the laptop computer using a serial adapter cable and the software included with the camera. The images are automatically compressed using the Joint Photographic Experts Group (JPEG) algorithm, and cropped as necessary. This results in file sizes of 30–250 kilobytes, depending on whether the image is 256-gray scale (for radiographs) or 24-bit colour. The images are then attached to e-mail containing the necessary clinical information and transmitted by satellite phone or land line via the Internet directly to the Haslar e-mail address. Typical file transfer times are 15 s to 2 min.

Patient confidentiality is preserved by use of code numbers for each patient and avoiding mention of details that could identify the patient. There is therefore no need for encryption software.

Results

The Olympus C1400L (Fig. 1) was used to take a wide variety of images in the military hospital under differing light conditions. These images were of X-rays, of patients’ wounds, of electrocardiograms, of burn injuries, of skin and eye lesions, and even of blood films through a microscope.

Images of 60 patients were transmitted to Haslar from Sipovo between January and November 1998, and another 73 referrals were made between July and November from new links set up in Gibraltar, the Falkland Islands, South Georgia, Cyprus and Belize (Table 1). There were 11 plastic surgical referrals during this period (Table 2). The first author saw most of these patients in the UK shortly after initial telemedicine referral. It was possible in all of these cases to validate the telemedicine images as having been reliably diagnostic.

Case reports

Patient 1

A soldier presented in Sipovo one day after a burning rag soaked with benzene fuel had flown up into his face from a refuse fire. He had immediately doused himself in cold water. He complained of blistering to the face, an itchy right eye and diminished sensation to the edge of the right nostril. There was no inhalational injury. He had a mixture of epidermal and superficial dermal burns to the right side of the face and neck (Fig. 2). He was treated with saline cleansing, moisturising cream, penicillin and chloramphenicol eye ointment. Images of his facial burns were transmitted to the Royal Hospital Haslar for review by the first author, who endorsed the treatment regime. His burns healed fully without scarring.

Patient 2

A 45-year-old officer presented with a 5-year history of a painless skin lesion on his face, in the left nasolabial fold. This lesion had slowly grown to form a shallow 2-cm-diameter ulcer, with encrustation in the base and raised pearly edges. A clinical diagnosis of a basal cell carcinoma was made. Images were transmitted to the first author for confirmation of the diagnosis and initiation of treatment (Fig. 3).
The patient was reviewed in Haslar a few days later so that excision of the lesion and advancement of a flap to cover the resulting defect could be expeditiously arranged.

**Patient 3**

A Bosnian soldier was injured in a land-mine explosion in April 1998. Amongst other injuries, he sustained a shrapnel wound to the left hand. After performing initial wound excision (Figs 4, 5), the orthopaedic surgeon in Sipovo sought the advice of the plastic surgeons at Haslar regarding further management. Advice was given which facilitated the soldier’s transfer to the care of a plastic surgery unit within his country.

**Patient 5**

A young soldier was involved in a brawl and had part of his right pinna bitten off (Fig. 6). The avulsed portion was trimmed and sutured back on in Sipovo, but soon became necrotic. At this stage, advice was sought from the plastic surgeon via the telemedicine link. Subsequent management and arrangements for his transfer to Haslar for formal reconstruction of the pinna were facilitated by the e-mail link and review of sequential images transmitted from Bosnia.

### Discussion

The main aims of this low-cost telemedicine link were to provide specialist advice to isolated clinicians on operational deployment and, if possible, to prevent unnecessary and expensive aeromedical evacuation. The opportunity was also taken to see if advances in digital camera technology had reached the stage whereby such a camera could provide sufficiently high resolution for reproduction of X-ray pictures as well as clinical images, without recourse to flatbed scanners.

These aims were achieved by the use of the Olympus C1400L (superseded in November 1998 by the equally high-resolution Olympus C1400XL costing under £1000), and by the transmission of still images as e-mail attachments. The image quality with these cameras is excellent, allowing reliable diagnoses to be made in all cases. Because these are digital images, there is no deterioration whatsoever in their quality as a result of transmission, whether by land line or satellite phone. All images in this article are as received at Haslar. The store-and-forward method of e-mail transmission has worked satisfactorily in all cases. There is no need for video-teleconferencing. Examples of the different types of images that have been transmitted can be viewed on the telemedicine
It should be emphasised that a web site is not required for this telemedicine system, as e-mail with accompanying images is sent directly to an e-mail address.

The ease of use of this camera-based system and e-mail transmission has particular appeal in an emergency situation, where urgent specialist opinion is required. This is very relevant for burns and traumatic injuries, especially if advice has to be sought from a tertiary centre. Our experience is in keeping with previously reported experience in the United States, where digital photographs of mutilating extremity injuries have been transmitted by e-mail from casualty departments in order to obtain urgent specialist opinion as to the suitability for replantation.

Civilian use of the Internet to send clinical images as e-mail attachments over land lines has been reported. Several of our images were sent via land line from Bosnia. The use of satellite telephones is not necessary in the UK, though it may be crucial in a military context elsewhere. The use of land lines with this telemedicine system drastically reduces the setup costs, limiting them to the camera, a tripod and close-up lenses, a computer at either end of the link, modems,
image manipulation software, Internet service provider subscription and local-rate telephone bills.

The Internet is increasingly being used by plastic surgeons for exchange of clinical information and to keep the general public informed. The librarian at the Royal Hospital Haslar has developed a Web page with links to a wide variety of medical resources on the Internet, including plastic surgical web sites, which we have found very useful.

This project represents another contribution by the military to the evolution of plastic surgery. It has provided very useful practical experience in telemedicine for plastic surgeons in the British Defence Medical Services. It has helped define the applications of telemedicine to plastic surgery and other specialties and reinforced our opinion that an effective system can deliver the necessary quality without being expensive. It does, however, require enthusiasm and a willingness to adapt to modern technology for the benefit of our patients.

Conclusion

The British Defence Medical Services Telemedicine System has been very helpful in the management of a number of plastic surgery and other cases over the last year. Its ingenuity won it a Special Award for Information Technology from the prestigious British Computer Society in November 1998. Its simplicity, its cheapness and its versatility make it useful in both a military and a civilian context, anywhere in the world. It has the potential to drastically alter the pattern of referrals by general practitioners, hospital doctors or accident and emergency departments to the highly visual specialty of plastic surgery.

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