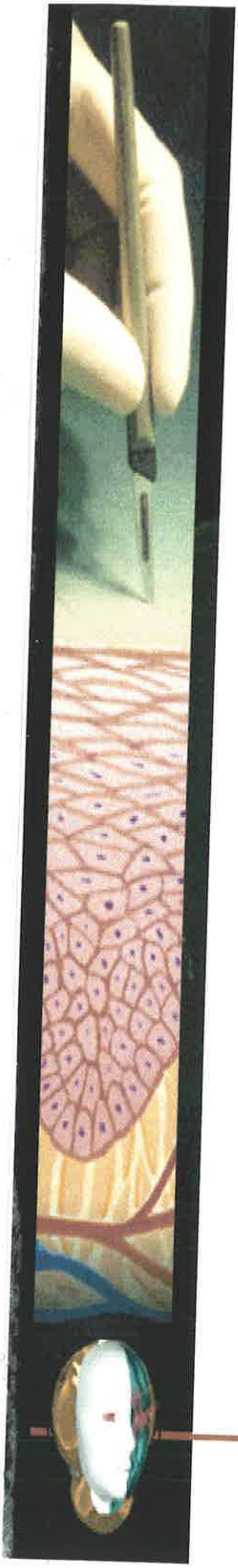


Multi Media Applications In Medical Education: Evaluation Of An Interactive CD-ROM On Practical Skin Wound Management For Medical Undergraduate Learning

A Thesis Submited for the Degree of Master of Surgery

by Peter Sylaidis MBBS (Flinders), FRCS, FRCSI

Department of Surgery, University of Adelaide

Submitted for Degree in January 1999

Practical Skin Wound Management

Multi Media Applications In Medical Education: Evaluation Of An Interactive CD-ROM On Practical Skin Wound Management For Medical Undergraduate Learning

A Thesis Submitted for the Degree of Master of Surgery

by

Peter Sylaidis, BMBS (Flinders), FRCS, FRCSI

Dept of Surgery,

University of Adelaide

Submitted for degree in February 1999

DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give my consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Peter Sylaidis
February 1999

TABLE OF CONTENTS

SUMMARY

The practical management of skin wounds is a significant component of any primary health care service. Traditional teaching of this topic to undergraduate medical students has been fragmented in many curricula, so that general practitioners often gain only anecdotal knowledge in this field by the time they enter clinical practice. While this subject lends itself to multi-media education, no applications have to date been tested and reported. Additionally, there are few studies assessing the effectiveness of computer assisted learning of motor skills in general. In view of the rapidly developing international interest in both multi-media and virtual reality applications for surgical procedures, the introduction of interactive teaching formats into medical undergraduate curricula is a logical progression from the traditional classroom delivery of practical wound education.

To address this hiatus in medical education, an evidence-based multi-media application entitled "Practical Skin Wound Management" (PSWM) has been developed by the Plastic Surgery Service of The University of Adelaide. In keeping with the modern trend towards computer assisted learning, an interactive CD ROM format was chosen to provide theoretical knowledge and practical skills tuition.

It was the purpose of this study to assess objectively PSWM as an educational tool for medical undergraduates. Eighty medical undergraduate students from The University of Adelaide were allocated randomly to control or treatment groups. Only the treatment groups received exposure to PSWM. Each group underwent an initial test of knowledge on practical skin wound management. After the test group's exposure to PSWM, repeat testing was performed on each group. The results indicated that PSWM was a highly effective undergraduate teaching tool, for both theoretical knowledge and practical motor skills relating to skin wound management. Of particular interest was the PSWM's effectiveness for teaching suture techniques and knot tying.

DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give my consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Peter Sylaidis
February 1999

ACKNOWLEDGEMENTS

In November 1997, Mr Rodney Cooter, Head of Unit of Plastic Surgery, at The University of Adelaide, offered me the opportunity to co-author a multi-media based, interactive CD-ROM program entitled 'Practical Skin Wound Management'. This proved to be a very interesting and successful project. The production team for this project consisted of: Mr R Cooter as producer and editor, Mr P Sylaidis as script writer, editor and director, Christian Kokai-Kun as multi-media programmer, Mark Stevens as team coordinator and clinical photographer, and Harry Slaghekke as the graphic artist.

Subsequent to its development, it was decided to test the effectiveness of this multi-media application in undergraduate medical education as a project for the degree of Master in Surgery. In relation to this project, I wish to thank my supervisors Mr R D Cooter MD, FRACS and Mr T W Proudman MS, FRACS. Sincere thanks are also given to the individuals listed below who helped to bring this project to fruition:

Professor G Maddern MS, PhD, FRACS, who has been very supportive throughout the project.

Professor D I Newble BSc (Hons), MD, FRACP, Dip Ed, has been very helpful with valuable advice during the structuring of the investigation and kindly reviewed this thesis, giving constructive criticism.

Mr M Bruening FRCS and Mr T Proudman MS, FRACS gave generously their time to be independent examiners of the student subjects used in this project.

Philip Leppard BA (Hons, Stats) provided the statistical analyses of the data.

Christian Kokai-Kun, multi-media expert, reviewed the relevant sections of the thesis.

Mark Stevens, clinical photographer, provided the colour prints.

Sandra Ireland and Kimberley Rohan, The Department of Surgery's secretarial staff, for generously assisting with the typing.

TABLE OF ABBREVIATIONS

AAMC	Association of American Medical Colleges
CAL	Computer Assisted Learning
GMC	General Medical Council
MM	Multimedia Applications
OSCE	Objective Structured Clinical Examination
PSWM	The multimedia application entitled 'Practical Skin Wound Management'
WWW	World Wide Web

TABLE OF TABLES

TABLE OF FIGURES

CHAPTER ONE

INTRODUCTION AND REVIEW OF LITERATURE

1.1 MEDICAL EDUCATION: A HISTORICAL PERSPECTIVE

1.1.1 Overview

The need to know how to care for wounds and perform surgical procedures is as old as the history of human affliction. The first archaeological evidence of formal surgical intervention is at least 10,000 years old and relates to skull trepanning (Newman1957). From these rudimentary origins the practice of surgery is evolving into an evidence-based, high technology science. This progress has only been possible by the development and transmission of ideas and experience. Such transmission from an informed and experienced practitioner to another constitutes medical education. The process is unalienably inter-woven in the fabric of the evolution of medical practice, however its importance has not always been as valued as it is today. A review of the history of medical education reveals a rather haphazard and sometimes chaotic sequence of events prior to the mid-19th century (Porter 1996).

1.1.2 Medical Education in the Ancient World

The earliest formal documentation of surgical procedures is credited to the Babylonians and Egyptians dating back to the 2nd millennium BC. Medical papyri and stone carvings refer to surgical procedures for abscesses, minor tumors and disorders of the ears, eyes and teeth. However the first body of medical literature was written by the Hippocratic practitioners of the fifth and fourth centuries BC (Porter 1996). Hippocrates (460-379 BC) of the Greek island of Cos is honoured with the title of "Father of Medicine" as his teachings came to represent the beauty, value and dignity of medicine. Up to 70 books have been attributed to Hippocrates but they are more likely a compilation by many authors. These were collected in Alexandria during the 3rd Century BC and were entitled "Corpus Hippocraticum". These texts placed great emphasis on the value of observation of disease processes and practical treatments consisting in the first instance of diets, and on occasion, body cleansing, vomiting, and blood letting. If these measures failed, then drugs were used. Surgical procedures were used only as the last resort. The fundamental Hippocratic assumption was that nature ("physis") was a strong healing force and its tendency was to return the body to a state of balance and health. Disease was seen as a disharmony of these forces. Of the seven main essay topics covered in the Corpus Hippocraticum, one was devoted to "nomos" or "law/rule", which discussed medical education (Ackerknecht 1982).

Nomos embraced professional attitudes, ethics and conduct. Some mention was made of pre-requisites for training, but there was no direct reference to medical curriculum (Levine 1971). In fact medical education is a modern term. Education up to the mid 19th century meant moral and intellectual discipline which focused on the imparting of values and building character rather than vocational training (Rosner 1997). In the early classical Greek period, medical training consisted of serving experienced practitioners, attending discussions on the theory and treatment of disease, plus reading the available texts. Great importance was paid to personal inspection, examination and treatment of patients by students (Ackerknecht 1982, Lawrence 1993). However there was no fixed medical curriculum. The early Greek medical schools of Cos and Cnidos in the late seventh to third centuries BC and later Alexandria, emphasised obtaining practical hands-on experience while being apprenticed to an experienced physician (Rosner 1997). Such a commendable attitude towards medical tuition was unfortunately overwhelmed by the persuasive influence of Greek philosophy, as championed by the great Aristotle (384-322 BC), who emphasised theory and abstract thought. Due to the widespread influence of such powerful abstract thinkers, the practice of medical education changed. Philosophical and theoretical reflections gradually attained greater importance than the practical Hippocratic model. This trend was criticised by the Greek "empirics" of the 3rd century BC but their voices of concern were blanketed by the famous philosopher-physician Galen (3rd century BC), who insisted that the true physician be a philosopher. The Hippocratic proponents considered treatment of the disease as being of primary importance, where as the Galenic physicians, being able to explain the disease was the mark of a true physician, so they became pre-occupied with the study of abstract disciplines. The great Greek literate tradition was to have an overwhelming impact on the development of Western thought in the ensuing two millennia. Unfortunately, by being part of that tradition, Galen's legacy largely determined the shape of medical education well into the scientific revolutions of the 18th & 19th centuries. The effect was to change the practical, holistic approach of medicine to an abstract, theory-based discipline. This separation of theory from practice had many repercussions and it has taken over two millennia to return to the holistic Hippocratic approach (Lawrence 1993, Rosner 1997).

1.1.3 Medical Education in the Middle Ages

The Hellenistic corpus of medical knowledge shaped medical education throughout the Eastern Roman Empire (Byzantine), Islamic territories and Western Europe throughout the Middle Ages and medieval period. Hippocratic, Aristotlian and Galenian works were translated and become established texts for the theory, philosophy and practice of medicine.

The main educational developments of the Middle Ages included the establishment of hospitals and relatively stable medical schools. These emerged in the Byzantine empire in the 5th century AD and students attended the hospitals for clinical experience under officially appointed physicians. Similar hospital-cum-medical schools appeared in major Islamic cities by the 8th century AD. However Western Christian hospitals were little more than monastic infirmaries providing only basic nursing support well into the 13th and even up to the 17th century AD. During this period in Western Europe, there was very little input by physicians to the care of patients in these hospitals. Consequently there was no practical clinical training provided for students at these sites. Indeed, medicine developed along two very divergent lines. The first was University-based which centered on textual study, largely based on the Greco-Arabic literature. Such education was reserved for the teaching of internal medicine and thus produced only physicians. It was by its nature highly philosophical and largely theoretical with negligible hands-on training. The courses were largely unstructured with little time spent on directing students on the bedside care of patients. Medical degrees were awarded for an antiquated knowledge of disease theory and philosophy of medical practice, but not for clinical experience. This doctoral approach became the standard teaching method for producing learned physicians.

Surgery developed along different lines and was considered a non-academic 'hands-on' vocation and was not taught in a university. Additionally there was a religious prohibition against clergy (university educators) shedding blood by the 13th century AD and this further severed any links between surgery and internal medicine. Surgical training was therefore excluded from the universities. Consequently surgeons retreated to the urban guilds which had an apprenticeship-based training structure. Membership of a Barber-Surgeons guild required apprenticeship to a practicing member for a number of years followed by an oral examination. Training in this setting was even less structured than education at a university. Apprentices were legally bound to their masters to whom they were little more than unpaid servants. The apprentices' education was left entirely up to the masters, hence was of a highly variable quality. The first few years were spent carrying out the duties of a servant and only gaining access to surgical tasks after a period of time and at the pleasure of the master. Though there was a growing body of surgical literature by the late middle ages, guilds did not require examination of such knowledge. This situation helped to maintain the separation between theory and practice and remained so, well into the early 19th century (Lawrence 1993, Newman 1957).

1.1.4 Medical Education in the Renaissance and Early Scientific Era

During the Renaissance and early scientific period, spanning the 15th to 18th centuries, medical education remained largely unchanged. It was subject to swings in emphasis between a Hippocratic experiential education and a Galenic theoretical based education. However there were three new forces which began to challenge the established traditions; the development of the printing press, the Protestant Reformation and the Scientific Revolution.

The printing press helped to make more readily available medical literature both old and new. It also helped to disseminate discussion and criticism of the Greco-Arabic medical theory and practice which had remained unchallenged well into the 16th and 17th centuries. The Protestant Reformation was a catalyst for changing all things of the Catholic establishment, including the practice of medicine. This new stream of inquiry and re-appraisal was markedly fuelled by the discoveries of the scientific revolution. Dissatisfaction with the predominantly philosophical theory-based approach of the old traditions resulted in a return to a patient-based approach. This was initially encouraged by the Paduan medical faculty (16th century) in Italy by its use of bed-side teaching. So successful was it that Padua became the major centre for advanced medical education in the 17th century for all of Europe. This approach was developed by other Universities, but most notably at Leiden (17th & 18th centuries) which opened small wards for patients with conditions of particular teaching interest. Appointed physicians could then demonstrate to their students how to apply textual knowledge to patients' particular conditions. This model greatly influenced medical education in the United Kingdom after being adopted in Edinburgh. Though a major step forward, this model was still largely based on the didactic transmission of knowledge and did not offer students the opportunity to examine patients for themselves, let alone prescribe and give treatments as in the true Hippocratic tradition (Lawrence 1993). This renewed interest in clinically-based teaching escalated in the latter half of the 18th century, when at least six months of "walking the wards" was considered essential clinical exposure before obtaining a degree (Rosner 1997). However such clinical exposure was still disorganized and the student was left to structure his own curriculum of clinical experience (Newman 1957).

1.1.5 Medical Education in the 19th Century

Concurrent with escalating demand by medical students for more clinical training the surgical apprentices were, by the end of the 18th century, actively seeking more theoretical and scientific teaching. This overlapping interest resulted in a significant restructuring of medical education in the 19th century, with the reunification of medicine and surgery. This reintegration was championed by a revolution in Paris at the end of 18th into the early 19th centuries. Reformers dismantled the old system, physicians and surgeons were required to attend the same medical school and follow the same curriculum based on didactic teaching, textual study, observation of qualified practitioners plus some hands on examination of patients. Specialties training in medicine or surgery were developed in the later years of undergraduate education (Lawrence 1993, Newman1957). This unification gradually spread to the other western universities during the 19th century (Bonner 1995 , Lawrence 1993). By this time there had evolved a structured 6 year long curriculum with the first half covering: anatomy, Materia Medica, pharmacy, chemistry, botany and natural history. The second half dealt with: clinical medicine, the practice of medicine, surgery, clinical surgery, military surgery and midwifery (Lawrence 1993).

Unification markedly increased the workload of students. This was further expanded by the development of clinical skills as a result of new medical technologies, for example the ophthalmoscope (1815), stethoscope (1816) and X-ray imaging (1895). Furthermore, basic sciences such as physics, chemistry, biology, physiology, anatomy and the newly discovered bacteriology, were rapidly expanding. In addition to this, medical sciences were evolving as a result of the collection and categorisation of objective observations of diseases in-patients, organs, tissue and fluids. These endeavours resulted in the development of morbid anatomy, pathology, histology, microbiology, and biochemistry. Due to these rapid advances , there was very heated controversy in the later part of the 19th century about the structure and emphasis of a proper medical education. Medical researchers insisted on there being a scientific basis to the practice of medicine, whereas clinicians insisted upon the need for development of clinical skills and refinement of clinical practice. These issues were largely resolved in the earlier part of the 20th century (Lawrence 1993).

1.1.6 Medical Education in the 20th Century

International controversy over a standard form of medical education was largely resolved by the recommendations of Abraham Flexner (1866-1959). His report 'Medical Education in the US and Canada' (Flexner 1910) recommended that: " a medical school should be part of a University, teach basic sciences in a liberal arts department; have its own departments for the biomedical sciences to encourage research and advanced instruction; and have a teaching hospital with clinical departments in both the medical school and the hospital; have high entrant requirements, a graded curriculum and end with a doctoral degree". Flexner's vision was one of scientific medical training producing highly trained medical professionals (Lawrence 1993). It was so influential that it still constitutes the traditional style of medical undergraduate education in North America, United Kingdom, Australia, and many other countries throughout the world. It was so solidly accepted that it remained largely unchallenged for over 60 years.

By the 1970's, several short-comings of the Flexner model became widely recognised, these were: factual over-load, lack of sufficient integration between science with clinical practice, over-emphasis on specialty medicine, over-emphasis on investigating and treating individual cases and too little exposure to teaching community health and preventative medicine,

Factual overload on the students was recognised as a developing problem by the end of the 19th century. Throughout the 20th century, curricula continued to be augmented by the escalating scientific discoveries and the trend towards medical specialisation. This has been, and continues to be, a major concern to medical educationalists. A number of initiatives have been taken to correct this problem. The General Medical Council (GMC 1993,1980) has suggested that educators aim to produce undifferentiated, self-motivated graduates who may proceed to post-graduate studies in their area of interest and be pro-active in keeping up to date with self-directed, on-going education. This effectively reduces factual over-load by decreasing the amount of 'specialty' training that students were exposed to. To achieve this educational goal, the GMC recommended that training be reduced to a 'core' curriculum based on essential subjects with additional special study modules eg. electives and project work, to encourage special interests. Both the GMC and the Association of American Medical Colleges 'AAMC' (Curry and Makoul 1998) have emphasised the need to decrease passive learning by reducing exposure to didactic lectures and encouraging active, self-directed learning by using small group tutorials, problem based learning and `guided self-learning. Critical thinking is considered to be very valuable, especially with today's emphasis on evidence based medicine (Coles 1996, GMC 1980). Students are now actively encouraged to independently seek out information and training. It was stated that "computer assisted learning will substantially increase the scope for self-directed leaning" (GMC 1993).

The tendency for science to remain separate from clinical practice is demonstrated by the traditional division of curricula into pre-clinical and clinical years. In fairness, this is in fact contrary to vision of Abraham Flexner. It has been suggested that this factor has been a significant contributor to factual overload of curricula. The GMC (GMC 1993) and the AAMC (GPEP 1984) has recommended that this may be remedied by encouraging formal dialogue between the higher training bodies. Curricular courses based on departmental disciplines are "to be abandoned in favour of those relating to systems of the body or topics of relevance to the overall scope of the course" (GMC 1993). The University of Newcastle is a good example of this, where the scientific and clinical aspects of medicine are taught together throughout the course (Sajid et al 1994).

Until the 1980's, students were predominantly exposed to specialist orientated tertiary care rather than more widely needed primary health care. Medical schools were linked to teaching hospitals, which were practicing tertiary care. Students were therefore exposed to the diagnosis and treatment of serious illnesses, even if rare, at the expense of less serious conditions, which may be wide spread and disabling. The concepts of disease prevention and health promotion were under-emphasized. The result was the production of technology dependent tertiary-care orientated medical graduates. This issue was strongly addressed by the World Health Assembly, which endorsed the evolving concept of undergraduate training in primary health care. There were initial concerns in the academic community that the closer links between medical education and the primary health services would undermine the academic standards. However, the World Health Organisation stood firm on this issue and made the Alma Ata Declaration in the USSR in 1978, which stated that "the highest standards in medical education for any country is that which is most responsive to local needs" (World Health Organisation 1978). This emphasis has encouraged a global shift of medical education to re-emphasise patient contact and training in primary health care. This is evidenced by the changing medical curriculum to include topics of primary health care (World Federation for Medical Education Report 1988, Sajid et al 1994, Rees 1993).

Due to these types of influences, medical curricula are changing, especially in the more progressive teaching centres, from a teacher-orientated, didactic, medical-science model to a student-orientated problem-based learning model with greater emphasis on community-relevant medicine (Ragachari 1991). Additionally, undergraduate training is moving away from its specialist-centred style and becoming more 'undifferentiated'. The goal is to produce self-motivated, critical thinking graduates who may then pursue further post-graduate studies in an area of special interest in response to community need (Doherty 1988).

1.1.7 Australian Medical Education

Australian medical education is heavily modelled on the British pattern. This is not surprising considering that until 1986 the British General Medical Council was the formal accrediting body for medical schools in Australia. Since then this responsibility has been transferred to the Australian Medical Council. Changes to the Australian system for medical education have closely parallelled those of Britain. The system is based on the traditional Flexner model, which evolved in the late 20th century, to produce undifferentiated doctors of a particular standard, who were able to both respond and actively participate in ongoing medical education (Doherty 1988).

Until very recently, Australian Medical Schools had undergraduate programs, which were similar in structure and content, with two distinct educational phases. The initial pre-clinical phase which ran for 2-3 years and was conducted mainly in the University. The subsequent clinical stage was mainly conducted outside the University, predominantly in a teaching hospital or other health facilities affiliated with the school. The only medical school offering a program significantly different has been The University of Newcastle and Flinders University, which are regarded internationally as models of problem-based learning, vertically integrated schools. However, the scene has dramatically changed in recent years with more schools becoming graduate schools, each adopting a problem-based curriculum. The remainders are undergoing substantial reform with major changes in selection procedures, with trends to varying degrees of horizontal and vertical integration, introduction of problem-based learning and an interest in fostering self-directed learning. All the Australian medical schools now see diversity and flexibility of medical curricula as desirable goals. Furthermore, in response to an international trend toward primary health care training, their teaching methods have become more community based and student orientated. By incorporating primary health care and rural medicine topics into their medical curricula, the Australian medical schools have embraced the precepts expounded by the Karmel report of 1973.

1.2 MEDICAL EDUCATION AND THE ELECTRONIC INFORMATION AGE

1.2.1 New Information Technologies in Medical Education

The 18th and 19th centuries witnessed the re-integration of theory and practice manifesting as the reunion of medical with surgical teaching within a common institution. The 20th century has seen a strengthening of this alliance between medical science and practical clinical management. 'Holistic' and 'evidence-based' are commonly used descriptions of the preferred type of medical practice in the closing decade of the 20th century. Medical education now spans several different, though allied specialties It is trying to interrelate, in a practical way, the molecular (biochemistry) to the macro-molecular (genetic) to the cellular (cytology, histology, microbiology) to the organ systems (physiology, pathology) to the human being. Selecting representative material from such a diverse range of subjects without overwhelming both the system and the student is a great challenge to the educators. To their aid has come the computer with its more flexible modes of delivery of educational materials and programmes (Rosner 1997).

Computers have transformed rapidly our ability to process information, to such an extent that the fusion between computing and communications has launched us into what is being called the "electronic information age". The enthusiastic application of computer technologies and the associated Intranet/Internet developments have partly been stimulated by the explosion of available information but has also in part fuelled that very expansion.

This electronic medium is revolutionizing the transfer of information and knowledge in a magnitude comparable to the impact of the variable type printing press in the early Renaissance period. In preparing guidelines for medical education in the 21st century in the USA, the Project Panel on the General Professional Education of the Physician and College Preparation for Medicine (GPEP 1984) has strongly endorsed the use of such technology. The General Medical Council (GMC 1993) recognises that future development and availability of computer based technologies may revolutionise both medical education and practice. Computer technologies are already capable of offering the medical profession a host of valuable services in a variety of different formats. The availability of information technologies has already spawned a new discipline known as

Medical Informatics. Currently available services may be categorised as being either; information archives, electronic based communication and computer assisted learning.

1.2.2 Information Archives

It is possible to electronically compress and store enormous volumes of text and images on very little space. For example, a CD-ROM (computer disk- read only memory) may store 400,000 pages of text or 15,000 images (Nunnally 1994). Electronic medium in general have very low associated storage costs and enable very rapid retrieval of information (Schwartz, Lossef 1995 & Minorati et al 1995). New compression and storage technology advancements will continue to increase storage capacity eg. holographic storage.

Individual institutions are creating their own electronic archives for patient records, data bases, radiographic, ultrasonic and pathology images (Jaffe & Lynch 1993). These may be stored on the hard disks of individual departments' computers or made available to the institution by being placed on its Intranet. Bibliographical and other types of other databases has been made globally available by being placed either on CD-ROM or on the Internet. For example, CD-ROM and Internet versions of Medline have become a very popular reference tool and have taken over the role of the text based Index Medicus (Wee 1990, Curtis et al 1997). Medical information sources currently available on the Internet include; National Library of Medicine (http://www.nlm.nih.gov/), NHS Centre for Reviews and Dissemination (http://www.york.ac.uk/inst/crd/info), Uncover (http://www.carl.org/uncover), World Health Organisation (http://www.who.ch/) to name but a few (Kiley 1996). This information can be accessed from a personal computer in the office or at home, rather than going to the Library. It is believed that rapid access to archival information should enhance the quality of medical decision making and ultimately its cost effectiveness (Klemenz et al 1997).

The Internet and World Wide Web

The Internet is an interconnected network of computers linked by landlines, microwaves and satellites. All these computers respond to a common electronic signaling language, which allows them to exchange data regardless of their hardware or operating systems. It originated in the early 1960's as part of the cold war defence strategy. By 1972 it involved 37 interconnected University based computers but by 1998 it had increased to 12 million linked computers globally with network which is largely unregulated. The World Wide Web (WWW) is a protocol that runs on the Internet, which was developed initially in 1989 to help astronomers transfer information more easily between different computers. It was based on a marriage between hypertext (inter-links between documents) and the Internet file transfer protocol that facilitated the transfer of files between machines. WWW computers called "servers", run software programs that receive requests from other computers, called "browsers", and supply required files to the "users". Whereas there were only 50 operational WWW servers in January 1993, this had increased to 627,000 by 1998 (Carlile & Sefton 1998). The rapid development of the Internet and WWW has profoundly changed access to a vast range of medical information. The WWW is shaping up to be the world's greatest repository of rapidly accessible information and is universally available (Channin 1995). Although it currently remains uncatalogued in the conventional way, several working parties are examining this issue in an endeavor to standardize data formatting in the future (Carlile & Sefton 1998).

1.2.3 Information Transfer

Information and non-interactive communications may be transmitted electronically from one user to another either by facsimile via telephone pathways or by electronic mail (e-mail) on the Internet.

E-mail users can send large volumes of data and information to recipients internationally, almost instantaneously and at a fraction of the cost of traditional communications (Letterie et al 1994). The speed of delivery depends on the volume of network traffic, the message interlinks to reach its destination and the communication systems' bandwidths. The cost is determined by the duration of connection to a 'provider' (Kiley 1996). Besides being an efficient and rapid means of distributing data, e-mail can be and is used as an educational tool by joining 'Discussion lists' or 'Newsgroups'.

E-mail Medical Discussion Lists

Discussion lists are subject specific groups that participate by e-mail. Once enlisted, every message that is subsequently posted to that list is copied to a user's electronic mailbox. Letterie et al (1994) have reported success with e-mail as a means

of conducting a distant continuing medical education program. Clinical questions and reading reference lists were e-mailed out to the participants who were given 48 hours to respond by e-mail. These were assessed and feedback sent to participants within a fortnight. There are over 10,000 discussion lists on a spectrum of topics. The majority of lists are open to everyone therefore the quality of questions and answers may be highly variable. There are moves to create 'doctor-only' lists in order to improve the quality of posted information. To select a discussion list that more closely matches one's medical interest, one of the indexing resources can be consulted. Examples are:
Medical Matrix (http://www.slackinc.com/matrix/), or Health Web (http://www.ghsl.nwu.edu/healthweb), or the list-server database (http://www/liszt.com/) (Kiley 1996). This format may also be used for 'Telemedicine' where doctors or patients send their details including images to specialists who then return their opinion. For residents in outback Australia this service has particular relevance as an informed communication source for medical and surgical problems.

E-mail Medical Newsgroups

Newsgroups provide a forum for people to receive and contribute information and to update subjects of specific interest. There are over 15,000 such newsgroups. One may make a specific search for a newsgroup of medical interest by using the search engine Usenet Info Center (http://sunsite.unc.edu/usenet-i/search.html) (Kiley 1996).

1.2.4 Teaching Formats

While electronic archives, rapid data transfer and two way communication capacities are very impressive, for the medical educator the jewel in the crown of the information technologies lies with their ability to provide accessible inter-active multi-media based teaching programs and real-time, distant learning with educator-student interaction. The electronic information technologies have made available several very valuable ways for providing learning opportunities to users. It can provide conferencing facilities or present multi-media applications (MM) designed for teaching purposes. Conferencing facilities include both video-conferencing and virtual-conferencing. In both cases, an electronic interface is used to bring together distant participants for the purpose of exchange of ideas and information.

Video-conferencing and Virtual Conferencing on the Internet

Video-conferencing involves real-time audio-video images of conference delegates to enable immediate interaction. Virtual conferencing may have the delegates symbolically represented on screen so they may interact verbally or by textual images. In both applications, it is possible for the participants to simultaneously display multi-media based materials on screen and even electronic white-board information may be transmitted. These facilities effectively provide an electronic classroom with the students and educators located at different sites on the globe (Chodorow 1996). Examples of on-line conferencing services include:

- The INSURRECT project runs on the super JANET network in the UK which has linked up six teaching centres to provide interactive audio-visual learning in surgery to their undergraduates; these six universities are responsible for training 30% of all the British medical students and currently eighteen presentations are screened each academic term. The lectures consist of approximately 45-minute presentations and 15 minute question and answer sessions. The facility permits audio-visual transmission of questions from students at distant sites. The transmitted material is stored at a central provider for future access by any of the six sites. Such collaboration allows students access to a larger pool of surgical expertise than can be provided by any single institution. This is particularly important nowadays with the international push for improved surgical efficiency by; processing patients through day surgery facilities and increased channeling of patients to specific centers of specialization. These practices leave much less surgical teaching material in any one particular institution. A two year pilot INSURRECT course was completed in 1997 with 1,300 students participating in the 108 teaching sessions. The study found that the time spent by students at surgical teaching had increased by up to 50%. The impression of the educators was that the quality of teaching had markedly improved through this period. Furthermore, as a result of this initiative, two major curricula reforms were evolving in keeping with the GMC (1993) guidelines: firstly the collaboration between the six universities helped to define a core course for surgery, secondly, pre-clinical students were introduced to clinical material thereby moving toward vertical integration of the curriculum. (Jameson et al 1995, Hobsley et al 1997).

- The European Mobility Program for University Students, broadcasts video-conferencing medical courses for undergraduates and postgraduates to 20 central European countries. Broadcasts are live and interactive with participating doctors having the facility to question and challenge experts and opinion leaders (Young 1996).

- Video conferencing links have been established between the University of Aberdeen and the United Arabs Emirates University for exchange tutorials and discussions on gross pathology. It was found to be cost effective and very useful (Brebner et al 1997).

- A trans-Antlantic video-conferencing collaboration between professors and students at universities in Canada, England and Hungary is providing medical students with opportunities to experience cross cultural education in medical topics. It was felt that this experience gave the students the same benefit as an overseas elective period (Ostbye et al 1995).

- McLaren et al (1992) have reported a control study comparing video conferencing with face-to-face teaching for psychiatry to undergraduates. Their post test results showed no significant difference between the two methods indicating that video-conferencing was as effective as face to face teaching.

- The M.D.Anderson Cancer Center (http://utmdacc.mda.uth.tmc.edu/) at the University of Texas transmits live videoconferences on oncological topics, via the Internet. The facility allows distant participants to communicate directly with others. Its aim is to provide continuing education to distant primary care physicians (Kiley 1996).

- BioMOO (http://bioinformatics.weizmann.ac.il/BioMOO/) is a text and image-based virtual reality system for all members of the international biology community. It is a place to meet colleagues studying biology and related disciplines and is an arena for hosting conferences. Additionally BioMOO supports the simultaneous use of MM. The participants are not seen by video, instead they are listed on screen and one user may send messages directly to another (Kiley 1996).

Computer Assisted Learning

Traditional teaching methods include the use of written text, lectures, tutorial discussions, projected images, real time audio-video and bed-side teaching. Computer assisted learning (CAL) can combine these media and present them in a multi media format. Emerging CAL programs range in complexity from static, uni-directional formats of text only, or text plus still 2-D images, to highly interactive dynamic multi media applications (MM) to the newly arrived, interactive 3-D virtual reality simulations. Their potential applications range from being a simple electronic textbook to providing fully interactive, hands-on training experiences to highly skilled surgeons in advanced technical procedures (Rosser 1996). These technologies allow educators to design and create teaching tools that enable students to work simultaneously with material from different sources and even attend courses at different sites (Demirjan & David 1995). Currently multi media is the most popular form of CAL (Wright 1995).

1.3 MULTI-MEDIA APPLICATIONS AND MEDICAL EDUCATION

1.3.1 The Developing Role of Multi Media in Medical Education

Multi-media applications may simultaneously present material in different forms eg. text, audio-video, graphics, clinical photographs and animation with a high level of interactivity. It may take the user through the program in a "single step" didactic way or a "multi-step" interactive way. This interactivity is based on the use of 'hypertext' where the user is taken along different paths as a result of their choices or responses and the ability to allow the user to control the presentation and play of images. Due to this ability for interactivity, MM may be structured for the transmission of knowledge in either traditional didactic format, problem-based learning format or even provide simulated standardised patient encounters for clinical training (Devitt & Palmer 1998, Kiley 1996). As such it is able to interface between the didactic model of pre-clinical education and the clinical problem solving orientation of normal medical practice (Carlile & Sefton 1998). Due to this adaptability, MM is rapidly and profoundly integrating into medical education.

It is expected that interactive MM will play an increasingly important role in undergraduate curricula and post-graduate continuing education (Chodorow 1996). South and Nolan 1993 surveyed all the undergraduate medical schools in Australia and found that 36% of the Departments had some type of CAL. Sixty five percent of those who did not were preparing to introduce it or would like to do so in the near future. CAL was popular with students and the Heads of Departments felt it had significantly improved the standard of learning. Information technology applications were well developed in some institutions with Departments having up to 64 work stations and 200 packages available to their students. The University of Sydney's new graduate medical program is almost entirely structured around teaching material in the form of MM on the WWW (Coiera 1998). The University of Adelaide has developed and tested a novel problem solving, medical undergraduate MM entitled "Medici" (Devitt & Palmer 1998.) Educationalists believe that MM offers customised, self paced, self evaluating, time effective, educational opportunities to the user (Carlile & Sefton 1998). It is neither expected, nor desired, that CAL and MM substitute group tutorial interaction nor bedside clinical training. However it can be easily integrated into current curricula to serve either as supplementary or primary teaching methods. MM may be programmed to provide either didactic or problem-based learning. Additionally, they can provide the user with engaging opportunities to develop both their knowledge and clinical skills.

1.3.2 Cost-effectiveness of Multi Media

This medium is more time effective for faculty staff and students, while compensating for the every decreasing amount of clinical opportunities available to today's students and trainees (Devitt & Palmer 1998). However one major disadvantage of MM is the initial set-up costs for both hardware and software, which can be substantial. The Taylor report (Taylor & White 1991) from the Australian Department of Employment, Education and Training found that once the set-up costs are met, the running costs of using MM for tertiary school teaching are cost effective, especially for distance learning. However, independent production of MM is very expensive both in terms of time and money. Sometimes this may be avoided by purchasing commercially available MM. There are many medical, dental, nursing and allied health schools, associations and private companies which have entered into the development and production of medical multi-media titles (Wright 1995). In a cautionary tone, Glenn (1996) advises that a consumer-orientated model be used by medical course educators and curriculum designers to evaluate MM cost effective value. This should involve careful evaluation of the promotional literature which should discuss: the characteristics of the program, rationale for developing the program and its specific learning objectives, content, instructional format, teaching strategies, results of trials and meta-evaluation.

1.3.3 Sources of Multi Media

Currently there are three channels to access CAL multi-media titles. The first is the custom designed computer program designed to fill a specific educational role in a particular institution. Secondly there are commercially available CD-ROMs which encompass a wide range of multi-media titles and may be run on personal computers. CD-ROM is currently the most popular vehicle used for MM (Wright 1995). Of rapidly growing importance is the Internet and WWW which enable immediate global availability of teaching material and also permit constructional feedback from the user to the provider, who may then update the program. This facility will permit the evolution of educational programs and is setting the path towards a global University (Parker and Rossman 1992).

1.3.4 Implementation of Multi Media in Medical Education

A plethora of MM exists for training undergraduates and postgraduates. These range in complexity from simple text with still images to highly interactive packages with hypertext incorporating audio video and full animation graphics. However only a few have been published in the medical literature and fewer still have been formally tested for their effectiveness as teaching tools. A representative list of papers published on MM used for teaching undergraduate medical students is included in the Appendix A. The list was retrieved from a Medline search. In spite of the great enthusiasm for multi-media based teaching amongst its supporters, its introduction to medial curricula has been slow. Suggested reasons for this include: lack of sufficient proof of its efficacy (Devitt & Palmer 1998, Vickers 1990), initial set up costs, resistance to change (Allen, Walraven 1987) and concerns of clinicians at the thought of MM replacing person-to-person clinical exposure (Coiera 1988). Certainly MM have not been well evaluated by controlled studies and most reports are descriptive or subjective. Listed below are studies that have attempted to assess the usefulness of MM for medical undergraduate training. These are divided into two main categories: those that used MM as a stand alone tool and which compared it to another teaching method (eg. lectures), and those that used MM as a supplementary tool to a traditional teaching method (eg MM plus tutorial vs tutorial alone).

1.3.5 Comparative Studies with Multi Media Applications as Primary Teaching Tools

In the studies listed below, students were given either a MM or a traditional teaching method on a particular subject. The MM groups were not given any other teaching on the subject so the MM was used as a primary teaching tool. Comparisons were made between MM and conventional teaching methods as to their respective effectiveness in assisting learning by the students. Pre and post tests were used to quantify learning.

- Koch & Guice 1989: A randomised study comparing MM to traditional lectures for teaching electrocardiography in students. Post test results showed no significant difference between the two methods, but MM took half the time to complete.
- Mangione et al 1991: A randomised study comparing MM to seminar teaching with audiotapes to train students in cardiac auscultation. Post test results showed no significant difference between the two methods.
- Bresnitz et. al. 1992: Randomised study comparing MM to traditional lectures for teaching occupational lung disease to students. Post test results showed no significant difference between the two methods
- Bridges et al 1993: Non randomised study comparing MM to traditional lectures for teaching rheumatology to students. Post test results showed no significant difference between the two methods.
- Chew & Stiles 1994: A cross over study comparing MM to textbook study for teaching radiology to students. Post test results were significantly higher amongst the students using the MM.
- Sestini et al 1995: A randomised study comparing MM to traditional bedside teaching of breath sounds to students. Post test results at one week were not different, but at two weeks the MM group had a significantly higher score.
- Richardson 1997: A cross over study comparing MM to didactic lectures to computer lab assignments for teaching physiology to students. Post test results showed the MM group to have scored significantly lower than those attending didactic lectures.
- Devitt & Palmer 1998: A randomised study comparing MM to tutorial based learning for biliary disease. Post tests results showed no significant difference between the two methods.

The overall results found MM to be at least equal to traditional teaching methods when used as a primary teaching tool for either theoretical knowledge or clinical skills acquisition.

1.3.6 Non -Comparative Studies with Multi Media Applications as Primary Teaching Tools

In the studies listed below, students were only given MM based teaching. The MM were assessed for their effectiveness for assisting learning by comparing the pre to the post test results. No comparisons were made to other teaching methods.

- Papa & Meyer 1989: MM was used to teach emergency medicine to students. No control groups were used. Their post test results were significantly improved.
- Lonwe & Heijl 1993: MM was used to teach emergency ophthalmology to students. No control groups were used. Post test results were significantly improved with no risk to patients.
- Chew & Smirmotopoulos 1995: MM was used to teach skeletal fracture radiology to residents. No control groups were used. Post test results were significantly improved and the students preferred MM to their normal use of texts and plain radiographs or video tapes.
- Engel et al 1997: MM was used to teach diabetic nutrition to students. No control groups were used. Post test results were significantly improved. Their scores approached those of non-specialist dietitians. This was impressive as the students had only run a 30 minute program.

These studies found MM to be highly effective as a teaching tool for the learning of both theoretical knowledge and clinical skills. Papa and Meyer (1989) and Lonwe and Heijl (1993) emphasised the benefit of having these clinical learning experiences without inconveniencing the patient or putting the patient at risk.

1.3.7 Comparative Studies with Multi Media Applications as Supplementary Teaching Tools

In the studies listed below, students were given a traditional teaching method on a particular subject. The students were divided into treatment and control groups, the treatment groups received supplemental MM based teaching whereas the control groups only received the traditional teaching method. Comparisons were made between the treatment and control groups to assess the usefulness of supplementing traditional teaching methods with computer delivered MM based teaching. Pre and post tests were used to quantify learning.

- Desch et al 1991: Randomised study assessing the teaching of neonatology by one of three methods: MM plus traditional clinical teaching versus traditional clinical teaching alone versus traditional clinical teaching with supplemental prescribed reading. Post test results showed the first and last group did dramatically better than the clinical teaching only group. Significantly, the MM group required significantly less learning time than the group with the prescribed extra reading.
- Friedman et al 1992: This randomised study compared MM plus traditional teaching to traditional teaching only of bacteriology to students. Post test results were significantly higher for the MM supplemented group.
- Hong et al 1996: The cross over study comparing MM to students given no extra preparation prior to going to the operating theatre. Students were assessed in theatre by the senior surgeon using a 6 item questionnaire on their knowledge of operative anatomy. The students also completed an 8 item questionnaire on the quality of their operative experience. Significantly higher results were achieved by the students who had received pre-operative MM. Additionally the students found the tuition to enhance their experience of the operation while being very time effective.
- Mars & McLean 1996: Non randomised controlled study comparing MM plus traditional teaching to traditional teaching only of histology to medical students. The post test results were higher for the MM group, but this was not subjected to statistical analysis. Significantly, the MM group spent considerably less time in the histology microscopy laboratory.

The overall impression from these studies is that MM is a time effective teaching tool which may effectively supplement traditional teaching methods and established curricula.

1.3.8 Multi Media Formats

The aforementioned studies indicate that multi media based applications may be as effective as conventional teaching methods. Evidence suggests that it may be effective as either a primary or supplementary teaching tool or both. As a result of this confidence with MM, discussion has shifted from concerns regarding delivery technology to increasing interest in the instructional methodology (Wang et al 1997). Attention must be given to the format, presentation style, screen design, relevance of teaching material and to making it enjoyable to use (Carlile & Sefton 1998). For these reasons, a multi-disciplinary team approach to designing MM formats is recommended (Duguid 1995). They must be tailored to the type of learning experience one wishes to give to students. There are few studies on format structure but this may be considered as three types (Friedman et al 1991, Schwartz & Griffen 1993, Woolridge 1995):

1. Didactic: structured for the acquisition of knowledge.
2. Problem solving: requiring students to express specific diagnostic hypothesis and often management plans.
3. Simulated patient encounters: designed to provide opportunities to develop clinical skills on simulated standardised patients eg. history taking, physical examination, performing invasive procedures.

The didactic models give students access to information via hierarchical menus and provide explicit cues to help students master the content. This system is very useful in helping students acquire knowledge and learn the structure of clinical information.
The problem solving models require that students employ a formal clinical reasoning process. These models may be static, with the students only allowed to progress after scoring correct answers, or they may be dynamic where the simulated cases respond to the management decisions taken by the students. These programs also include varying degrees of educational feedback, both during and at the end of the program. Dynamic case simulations have undergone widespread development after the introduction of the relatively powerful and inexpensive microcomputers in the early 1980's.

Simulated or virtual patient encounters or computer controlled manikins, present an electronically-based patient which may be repeatedly manipulated by the user. The most advanced models allow the user to perform surgery on simulated sites which will bleed, provide wound retraction and expose the underlying structures. This is expected to be a major area of development with the advent of Virtual Reality Mark-up Language (for running 3D images on the Internet) and Artificial Intelligences.

To provide the most effective teaching formats, modern teaching principles should be observed. Rigid styles of presentation are unlikely to be well received by users nor accepted outside of an author's institution.

As with any type of teaching format the techniques used in MM need to be interesting and innovative. The careful designing of content, structure and the use of ancillary aids may achieve this. The quality of ancillary aids is very important as a means of being entertaining and stimulating. They include the use of graphics, cartoons, animated images and hot words, and informational feedback. These aids need to be of high quality and yet must not clutter the screen or distract the students from the content.

The structure of the format should allow the student easy access to sections of choice. A rigidly linear progression of subject matter in a program is to be avoided as this obliges the student to go over the material already known or of little interest.

Content should be, where possible, relevant to clinical practice and this should be highlighted by the use of relevant anecdotes, demonstrations and problem solving challenges. Adults learn best when they are able to apply their newly acquired knowledge as soon as possible. So a good MM should have a feedback loop in the form of an assessment which challenges students to use their newly acquired knowledge and skills. The assessment should present reasons as well as the correct answers. Using such informative feedback to provide the opportunity for further and remedial instruction is the hallmark of a good instructional module (Jelovsek et al 1989).

1.3.9 Multi Media Using Internet and Intranet Technology

The Intranet is a linked network of computers within a particular institution. It uses an identical platform to the Internet and therefore can be linked to it. An Intranet is a closed system and is used to perform functions specific to a particular institution eg. to carry procedure manuals, guidelines, and other confidential information. When linked to the Internet it may provide Internet access to users within its network. This is better than direct links to the Internet via modems that currently have a maximum speed of 56KB. The North Western Adelaide Health Services Intranet operates at 10MB. This greatly increases the speed of downloading information and images from the Internet. Off course the Intranet's speed depends on local traffic, however even at peak times, the user has at least 500KB to down load programs from the Internet.

The Internet has become a very rich source of MM of varied formats and styles. Being on the Internet, teaching materials are easily updated and offer feedback opportunities. Though we are still in the very early days of global electronic based medical education, there are strong indications that this will rapidly evolve. Already there are Internet sites providing an array of on-line educational applications from a global range of institutions (Carlile & Sefton 1998). Listed below are some of the more impressive sites:

- The Virtual Medical Centre (http://www-sci.lib.uci.edu/~martindale /Mediacal.html) offers a staggering 15,7000 MM medical teaching files and modules, 23,200 MM medical courses, 173 MM medical undergraduate courses/textbooks and 3,500 video clips.
- The Virtual Hospital (http://www.vh.org/Providers/CME/CMEHome.html) defines itself as a "continually updated digital health sciences library." Its aim is to provide 'distance-learning' to health care providers but also carries a lot of materials applicable to medical students. It has the reputation as carrying some of the best MM on the Internet.
- The Multi-media Reference Library (http://www.med.lib.co/medlibrary) provides a host of MM for medical undergraduates. (Kiley 1996)

Another exciting development of MM on the WWW is the growing availability and evolving complexity of the 'virtual patient encounter'. These are simulated patient encounters have been developed to help students develop skills in history taking, physical examination and structuring a plan of management. To date, the best available programs are located at the following sites:

- The Marshall University of School of Medicine in Huntington, West Virginia, USA has their "The Interactive Patient Encounter" on the WWW (http://medicus.marshal.edu/medicaus.htm). Users may take a history and perform a physical examination, order laboratory and radiological tests on these simulated patients. They then need to submit a diagnosis and a treatment plan. This system is capable of evaluating the user's performance and providing continuing medical education credits by mail to the user.
- The University of Colorado has its "Medical Rounds" on the WWW (http://www.uchs.edu/sm/pmb/medrounds/index.html). In this program you are

provided with the patient's details and are invited to discuss specific aspects of the casc. Reponses from the staff are e-mailed to thc participant within the week.

- The Stanford University has its 'Short Rounds Online" on the Internet which is similar to Colorado's.

1.3.10 Educational Information Technologies and Australia

The Commonwealth has taken an active interest in investigating, reviewing and encouraging the adoption and integration of new information technologies into the Australian education system. To date a number of reports have been commissioned by Commonwealth Departments, such as the Taylor & White Report 1991 entitled "The evaluation of the cost effectiveness of multi media mixed mode teaching and learning" and the Hesketh Report of 1996 entitled "Computer-mediated Communication in University Teaching" (Hesketh et al 1996). The Hesketh Report commissioned by the Department of Employment, Education, Training and Youth Affairs, found that there was a strong level of interest in the application of information technologies, both in tertiary institutions and in the Australian society as a whole. This was illustrated by an impressive list of governmental bodies that had been established to facilitate the dissemination and assimilation of information technologies throughout Australian society. In regard to higher education, several initiatives have been introduced to provide direction and support for the adoption of these technologies. These initiatives include:

- Open Learning Technology Corporation established in 1993 by Australia's Ministers of Education and Training to encourage the support for the provision of high quality cost effective open learning on a national basis.
- Educational Network Australia established in 1995 under the direction of the Open Learning Technology Corporation , to encourage the use of electronic networks by the secondary and higher education sectors.
- Open Learning Australia is a venture open to all Australians who wish to study University and TAFE courses by distance learning. It involves the collaboration of 29 Australian Universities and TAFE colleges and is assisted by the Australian Broadcasting Commission. In 1995 an agreement has been reached between Opening Learning Australia and the Commonwealth Government worth $A2.4 million to establish the "Open learning innovative and quality enhancement scheme". Its aim is

to encourage the development of teaching materials for on-line delivery. By May 1996, computer aided learning (http://www.ola.edu.au/olafacts.htm.) supported 15% of the course units.

- The Co-operative Multi-media Centre Program is an initiative of Creative Nation. Its aim is to encourage the development of Australian multi-media titles for education, art, commerce and technology. There are currently six co-operatives established in Australia. The University of Adelaide is associated with one of them which is called the Ngapartji Co-operative Multi-Media Centre. Its other members are: Flinders University; University of South Australia; South Australian TAFE; primary and secondary school education providers; arts and cultural bodies; and local industry.
- The Committee for the Advancement of University Teaching was formed in 1992 to help enhance the quality of teaching and learning in Australian Universities. It has a particular interest in the development of information technology and higher education. It financially supports such Australian-based projects with grants.
- The Professional and PostGraduate Education body was established to provide practitioners from a wide range of professions with continuing education materials. This is supported by a number of Universities across Australia and most of the subjects are broadcast by the SBS nationally and by ATV internationally.

Visionary and effective though these initiatives have been, the Hesketh Report (Hesketh et al 1996) points out that the adoption of their policies has not penetrated University teaching at more than a superficial level. The reasons for this are thought to be confusion, indecision, resistance, as well as a lack of resources and know how. Their impression was that, even though the University educators appreciated the arrival of the electronic information age and understood the need to keep in pace with developments, they remained cautious about its integration into the existing systems. The perception was that the technology will merely add time and pressure to an already over-burdened staff. This is a valid concern in view of the general deficiencies in information technology infrastructure, training and staff familiarity with new forms of teaching methodology. The report points out that student demand for these new teaching formats may well be a more significant stimulus for change. Students are becoming increasingly aware of the availability of more flexible delivery systems for teaching but the effect of a student-driven market force has not been fully assessed. The authors of this report were concerned that the application of information technologies in Australia is not proceeding as fast as in other nations. They recognised that the internationalisation of education has already begun and warned that Australian courses will not remain competitive unless they match this progress. They recommended that Australian educators become pro-active and develop professionally packaged CAL courses through collaborative efforts between the Universities as well as in partnership with private enterprise. Such a model has been successful in the U.K. and was used by the Unit of Plastic Surgery, Department of Surgery, University of Adelaide, for the production of a new MM entitled 'Practical Skin Wound Management'.

1.3.11 Multi Media Developments in the Department of Surgery at The University of Adelaide

The University of Adelaide, Department of Surgery has been at the forefront of information technology developments. Devitt and Palmer (1998) have developed an interactive MM for undergraduate surgical training entitled MEDICI. It uses clinical simulations and problem solving exercises to provide self-paced undergraduate teaching of diagnosis and management in general surgery. The program has been in place since 1995 and has been evaluated by a randomised comparative study. Eighty-four 5th year students were enrolled in the study and exposure to MEDICI was compared to tutorial attendance. Generally MEDICI was found to be as effective as tutorials for learning theoretical knowledge and clinical problem solving. Specifically, it was superior in the instruction of data analysis. The authors conclude that "the challenge for the future is not so much in proving to students that CAL is a worth while learning resource, but in persuading our colleges and fellow teachers that this is an effective and viable teaching medium, of proven educational worth".

The Unit of Plastic Surgery has been instrumental in teaching practical skin wound management to both medical students and general practitioners. Traditionally, much of the undergraduate and even postgraduate experience is largely determined by the quality of teaching received during their clinical attachments. Consequently there is much variation in the quality and quantity of tuition and training that is received from rather ad hoc exposure. Senior staff in the Unit of Plastic Surgery believe that undergraduates and junior postgraduate surgical trainees are often markedly deficient in their practical abilities to manage skin wounds. Furthermore, experience gained by staff at general practitioner conferences and practical skills workshops has made it evident that even experienced general practitioners could very much benefit from additional instruction on this subject. While workshops have been regarded as a very successful way of educating students and practitioners on wound management, there are major limitations in the numbers that can be taught in this way. Additionally, such methods are very much dependent on the quality of the lecturers, which may vary considerably.

1.3.12 Raison D'Etre For PSWM

In response to this perceived need to improve the education al delivery of practical skin wound management and with due sensitivity to the rapidly evolving multimedia communication systems applicable to medical education, the Unit of Plastic Surgery produced an MM on CD ROM entitled 'Practical Skin Wound Management' (PSWM). The content of this MM was tailored to meet the feedback suggestions of over 500 general practitioners attending practical skills workshops in the preceding 5 years. PSWM and was developed as a collaboration between the Unit of Plastic Surgery and the Cooperative Research Centre for Tissue Growth and Repair. This Cooperative has as its partners the University of Adelaide, the Commonwealth Scientific and Industrial Research Organization, the Child Health Research Institute and the Dairy Research and Development Cooperative. The Cooperative Research Centre was a major sponsor with the remaining untied funds coming from grants and donations.

1.3.13 Objectives of This Study

Having produced this MM the next goal was to test its efficacy as an undergraduate teaching tool. Multi-media applications have already been shown to be as effective as traditional teaching methods such as didactic lectures, reading text books, group tutorials and even bed side clinical teaching. To the author's knowledge, there have been no published studies to date, which asses the efficacy of MM for teaching students the theoretical basis of the practical management of skin wounds. Additionally, no MM has been reported nor assessed for its ability to teach suturing nor tying of knots, two very important clinical motor skills in the management of skin wounds. It was to fill these two gaps that the author conducted this prospective randomised study.

CHAPTER TWO

MATERIALS AND METHODS

2.1 THE MULTI-MEDIA APPLICATION ENTITLED 'PRACTICAL SKIN WOUND MANAGEMENT' (PSWM)

2.1.1 Content of PSWM

A multi-media format was chosen as the best way to present material relating to the practical management of skin wounds. Component modules are presented as a combination of text, graphic art, photographic images and real time video. Although video images place large demands on available memory space, they were considered important to display the 3-dimensionality of surgical ergonomics. Other images such as clinical photographs, graphic art, graphs and tables, are used to illustrate specific points discussed in the text. The text provides up-to-date theory and evidence-based practice relating to skin wound management. The range of topics presented include wound management decision making, pre-operative preparation, anaesthesia, operative intervention (eg. debridement), wound closure (eg. suturing), dressings and post-operative follow-up. As a prelude, PSWM provides tuition on skin anatomy and the biology of skin wound healing. The concluding module is a 'quiz' section where the participants are invited to test their newly acquired knowledge. To further facilitate learning on topic, all quiz questions provide the participant with additional information in response to them choosing the correct answer..

2.1.2 Format of PSWM

PSWM is an interactive multi-media application that has been designed with Multi-media Toolbook for operation on a PC platform. Interactivity is inherent in the content being presented as an interplay between fully referenced text, clinical photographs, original graphic art and real time video. The material seen by the treatment group students is demonstrated in Figures 1 to 41 in Appendix B. The program is very simple and user friendly. The users read the text by scrolling down the tool bar. The text provides factual information and describes the relevant operative procedures. Throughout the text are cues instructing the user when to click on a specific image or run a video clip. The text contains hash marks with numbers indicating which image screen button to click onto in order to see a specific image. For example, the symbol #3 means that the student should click on the third button in order to see the relevant image. There are also indications for when to play the videos of which there may be more than one per page. The users have full control of the images. They may choose which to see and in what order. They may also control the speed and direction of play of the video. Such interactivity with the images provides the user with the opportunity to repeatedly review a part of a procedure while attempting to perform the same.

2.1.3 Ancillary Aids for Learning Practical Skills

An innovative component of PSWM is that it provides the users with suturing and knot tying platforms on which to practice these skills while viewing on-screen examples. This feedback serves to reinforce the learning of these practical skills. Students are given polyurethane suturing platforms with simulated wounds on which to practice their suturing as they view the suturing sections. Such a platform, before and after use, is illustrated in Figure 2.1. They are also provided with knot tying platforms to practice their tying of knots as they view the relevant section on screen. These are made of large caliber, braided polypropylene cord to facilitate knot disassembly and re-use. Coloured cord is used to make clear the sequence of knot tying and to facilitate inspection of the knot. Figure 2.2 shows a knot tying platform before being tied and one after the knots have been tied.

2.1.6 Content of PSWM Used in the Study

As PSWM contains a large volume of multi-media based material requiring several hours to read, representative and relevant information was used for this prospective randomised study. From PSWM, three sections relating to skin wound closure were selected for testing by the students. These were:

1. Section 3 of module 1 which deals with the theory and practice of wound closure modalities, namely primary, secondary, tertiary closure and closure by epithelial regeneration. These are very important decision making concepts that are often misunderstood and confused by practicing clinicians. This deficiency reflects a lack of exposure to the topic in undergraduate teaching. .

2. Section 5 of module 5 deals with the theory and practice of suturing. Besides discussing the basics of good suturing, practical instruction is provided on the placement and tying of the five most commonly used percutaneous skin sutures, namely: single interrupted loop, vertical mattress, horizontal mattress, subcuticular and half buried horizontal (corner stitch) sutures.

3. Section 6 of module 5 deals with the theory and practice of tying knots. Accurate knot tying is obviously important in wound closure but often performed incorrectly by practitioners lacking formal tuition in the mechanics of knot tying. In this section students are taken through the development of knots from the pitfalls of a granny knot to the structure of a basic square knot, before the logical progression to the universal surgeons' knot. Considerable time was also spent explaining common errors in knot tying and how to avoid them.

These three sections were chosen as they are representative of PSWM and are of particular relevance to medical students education. Taken together, these three sections took the students approximately one hour to run and gave the examiners 100 examinable points to test them on. Independent examiners assessed the students' performances by comparing them with an ideal answer or technique.

2.2 MEDICAL STUDENT PARTICIPANTS OF THE STUDY

2.2.1 Selection of Medical Students for Testing the PSWM

Volunteers to test the usefulness of PSWM were recruited from the fourth and sixth year medical students at The University of Adelaide between April to July 1998, inclusive. Eighty students volunteered, forty 4^{th} years and forty 6^{th} years. These groups were assessed separately. Each group was sub-divided into treatment/computer and control groups. This was achieved by alternatively allocating students to one sub-group or the other. There were 4^{th} year computer and control groups, with twenty in each. There were also 6^{th} year computer and control groups, with twenty students in each. The computer groups received the PSWM program as an addition to their curriculum. The control groups did not receive the PSWM. Students exposure to skin wound management occurs to varying degrees, in all of their clinical attachments. Therefore it was not possible to rigidly structure the computer and control groups in order to make them truly comparative. That is to say, it was not possible to have the computer group only receive the PSWM and no other traditional teaching. Consequently it was decided to add the PSWM to the computer groups and compare their scores to the control groups who did not receive the PSWM.

The population variables considered were gender, age, English language skills and clinical attachments during the testing period. No attempt was made to match the groups, instead the students were randomly allocated to alternatively allocated to the subgroups. Statistical assessment of inter-group homogeneity of the above variables was conducted to be sure that potential population biases were not being introduced. Language skills were considered as a variable because not all students had English as their first language. However the investigator did not expect this to be a significant variable as the students had all obviously successfully passed at least the first three years of medical school, therefore their English language skills must have been advanced. Certainly they should have had no difficulties with the "reader friendly" text used in the PSWM program. However, to be confident of this, the computer groups were subjected to a five minute informal interview to check that their language skills were adequate to run the PSWM program, thereby excluding this as a possible variable. All the students were found to have satisfactory language skills.

In order to keep the groups isolated, the students in the computer groups were specifically asked to refrain from communicating PSWM information with the control groups.

2.2.2 The 4th Year Student Study Groups

At The University of Adelaide, medical students do not receive formal tuition on skin wound management in their first four undergraduate years. For this study the 4th year groups were considered as a naive population regarding the theory and practice of skin wound management. The 4th year computer group received PSWM whereas the control group did not. As this was the only scheduled instruction the 4th year students received during the trial period on skin wound management, PSWM acted as a novel learning experience and so this component of the study was a test of PSWM as a primary teaching tool. The 4th year control group did not receive any alternative structured tuition on skin wound management.

2.2.3 The 6th Year Student Study Groups

During their sixth year, medical students are expected to develop an understanding of, and relevant motor skills relating to, practical skin wound management. They are exposed to both acute and chronic wounds during their medical and surgical attachments. In addition they attend tutorials and practical skills workshops on different aspects of skin wound management eg suturing and knot tying tutorials using a pig trotter model. Material relating to skin wound management is examinable. Due to the presence of scheduled, traditional teaching on skin wound management, the PSWM program was considered as a supplemental teaching tool for the 6th year computer group. The control group simply followed their curriculum.

2.3 TECHNIQUE OF TESTING PSWM AS A LEARNING TOOL

2.3.1 Comparison of Learning Between the Computer and Control Groups

All tests used for assessing the computer and control groups were identical. The 4th and 6th year computer groups underwent an initial test (pre test), followed by one hour's tuition with PSWM, and followed by an immediate test (post-test 1) to assess immediate retention. A final test (post-test 2), was used one month later to assess long term retention. The 4th and 6th year control groups underwent the same pre-test, followed by a further test a month later (post test 2). They did not have access to PSWM, therefore post test 1 was not relevant for them. It may be suggested that the computer group had an unfair advantage in that they had the opportunity of doing the test three times compared to only twice for the control group. However the investigator is not aware of any convincing studies which support the idea that repeated exposure to a particular examination helps to significantly improve subsequent examination results. It is the feedback or newly acquired knowledge that improves subsequent examination results. The computer groups were not given feedback but they were given the opportunity to learn new knowledge while viewing the PSWM program. It is this gain in knowledge that the investigator wished to assess.

The students' normal teaching programs were not altered or influenced in any way. The pre-test was used to provide a baseline comparison between the groups. Post-test 1 was used to quantify learning and immediate retention for the treatment group students following exposure to the PSWM. Post test 2 was used to quantify long term retention, over a one month period, for the treatment group. Importantly, post-test 2 was also used to compare educational gains made by the control and treatment groups.

2.3.2 Structure and Method of Tests

The same test was given to the 4th and 6th year students. The pre and post-tests were identical. The test with answers, in full is shown in Appendix C. The test consisted of a written and an Objective Structured Clinical Examination (OSCE) component. The written component aimed to test theoretical knowledge while the OSCE tested practical motor skills competence. The written component consisted of 34 questions requiring a total of 55 single word or phrase responses. A number of

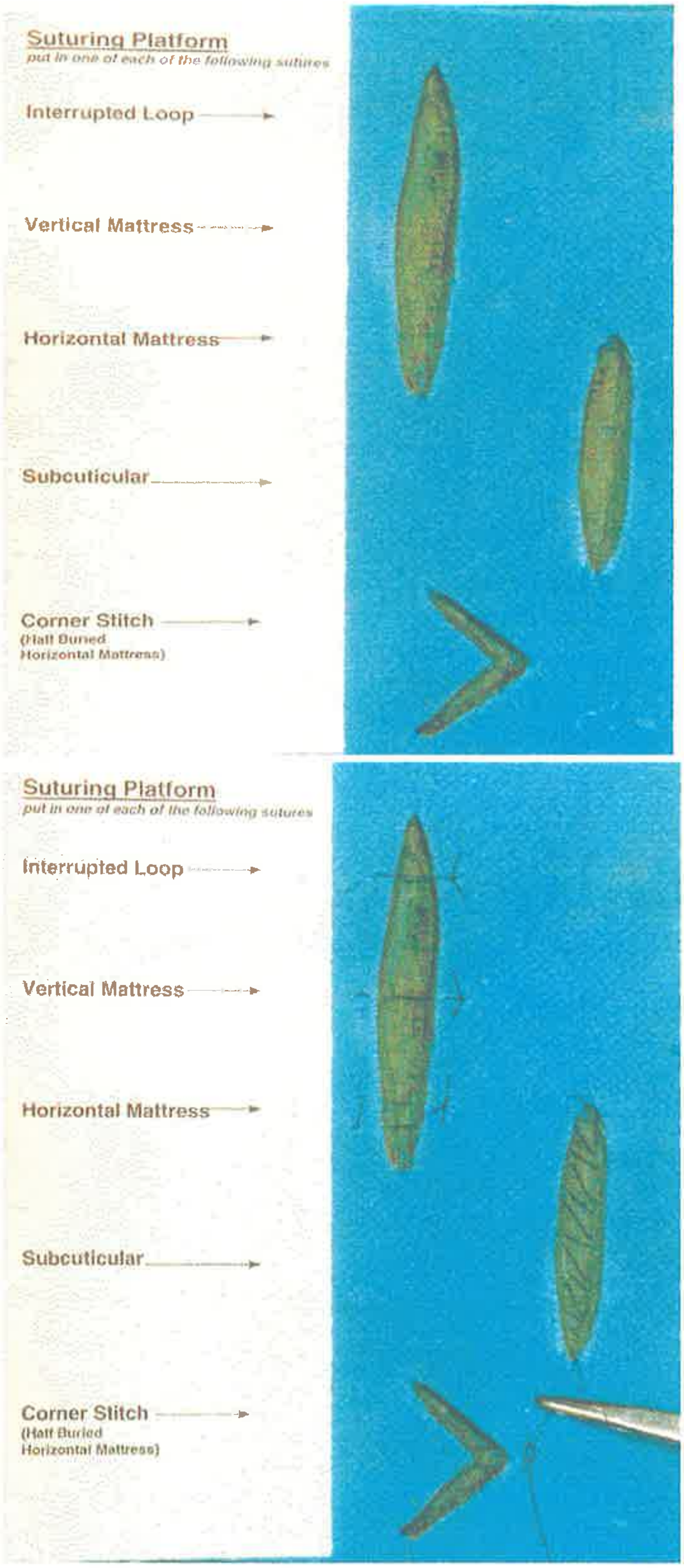
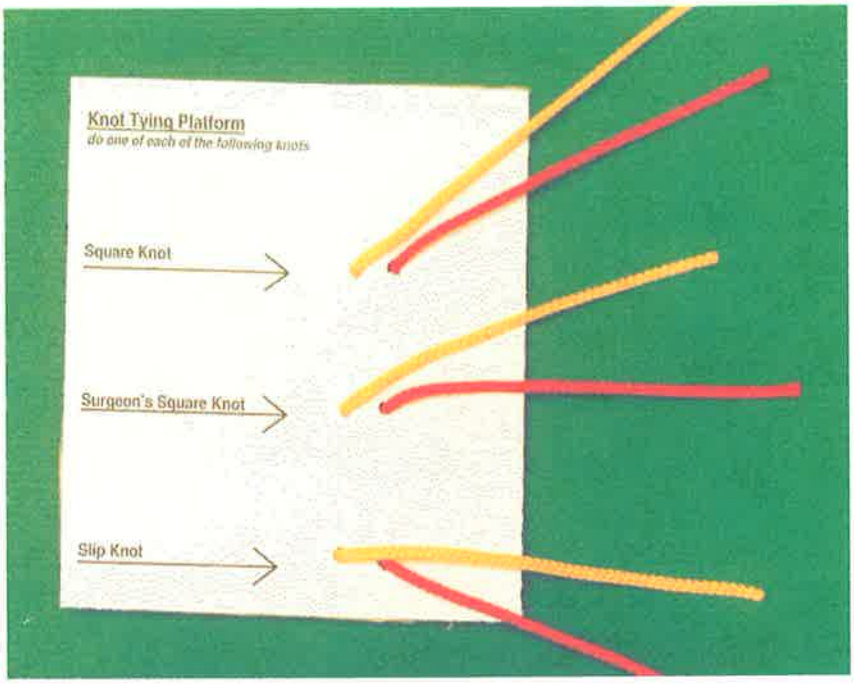


Figure 2.1 Suturing Platforms



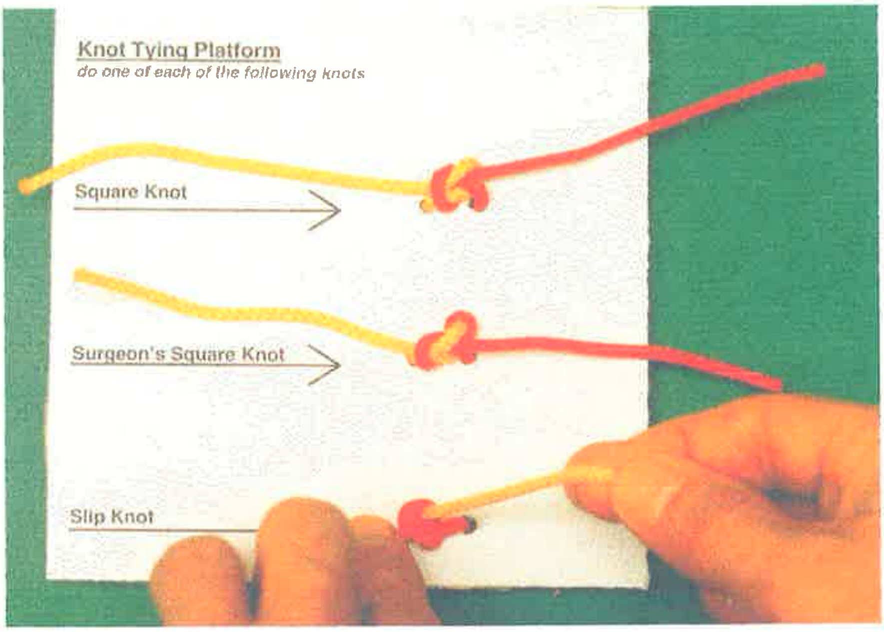


Figure 2.2 Knot Tying Platforms

questions required more than one answer. Each correct answer scored 1 mark, there was no negative marking. The OSCE consisted of 8 skill stations for suturing and tying knots, worth a total of 39 marks. The students were required to perform 5 different types of sutures and 3 different types of knots. Figures 2.1 and 2.2 show the suturing and knot tying platforms on which the students were required to perform their clinical skills. The students were instructed to place one of each of the required sutures in the mock wounds on the polyurethane foam suturing platform. There was a maximum allocation of six marks for each suture. Two marks were given for correct form of the suture, two for correct vertical symmetry, and two for correct horizontal symmetry. Emphasis on proper suturing techniques was made in the suturing section of module 5, and marked accordingly in the test. This marking system allowed for a more in-depth evaluation of the acquired motor skills of suturing. In addition to the suturing, students were required to tie one of each of the requested knots. The square knot received two marks, the surgeon's square knot four marks, and correct tying of the slip knot was awarded three marks. For the surgeon's square knot two marks were given for a double turn in the first throw and a single turn in the second throw and two marks given for it being a square knot, that is the ear and the loop exiting the knot on the same side (see figure 2.2). The slip knot needed to have at least two throws in the fashion of a slip knot. As for the suturing tests, the marking system for knot tying allowed a more in-depth evaluation of the acquired motor skills.

There was no time limit for sitting the tests nor for running the program. The emphasis was on quality of learning and tasks performed and not on speed, which only comes with time and experience. The students took approximately 30 minutes to do the written and 30 minutes to do the OSCE tests. It took the treatment group students, on average, one hour to run all three sections of the PSWM program. The students were supervised while they were performing the tasks. The suturing and knot tying platforms were collected and given to two separate examiners as discussed in section 2.3.5.

2.3.3 Selection of Test Methods for Theoretical Knowledge

The aim was to select a test that could effectively assess the students' learning of both theoretical knowledge and practical motor skills. There are two basic types of written examination formats for testing factual information (Jelovsek et al 1989):

1.Alternative choice questions eg. multiple choice, true or false, or matching statements.
2.Constructed response eg. short answer, fill in the blank, essays.

Alternative choice questions were not selected due to the significant incidence of students correctly guessing the right answer. Essays were not deemed appropriate for testing the factual information supplied by the PSWM therefore a short answer response format was chosen. The program provided 110 examinable factual points. The PSWM 'test blueprint' (Newble et al 1994) nominated that no more than 25% of the factual points come from Module 1 with the remainder from Module 5. By using these criteria and selecting the most clinically relevant pieces of information for testing, the examiners selected 13 questions from Module 1 and 42 questions from Module 5. The examiners were careful to select and write questions that were deemed fair to the control group. The selected questions were based on information considered essential to an experienced practitioner. It is important to note that the questions were not written to be equal to the students' level, but rather equivalent to an independently working practitioner. This was deemed appropriate as the aim of PSWM is to provide tuition up to this level.

2.3.4 Selection of Test Methods for Practical Motor Skills

The program provided tuition on 17 clinical motor skills of varying complexity. Following the PSWM 'test blueprint' (Newble et al 1994), 8 of the most clinically relevant skills were chosen for testing. To determine the effectiveness of clinical motor skills learnt by CAL is difficult and some authors consider existing evaluation techniques to be inadequate (Glenn 1996). This study placed considerable emphasis on assessing the clinical skills learnt from PSWM. An OSCE was used to test the students' clinical skills. This examination format has been shown to be an effective way of assessing the clinical competence of medical students (Newble et al 1994, Tervo et al 1997). These were performed on suturing and knot tying platforms. This enabled the author to collect and code the students' efforts in suturing and knot tying, then present these to the examiners at a later date. This removed any possible examiner bias, and removed the need for examiners to be present during the testing period.

2.3.5 Marking of the Tests

All tests were marked by two blinded, independent examiners. Examination papers and practical skills platforms were coded by the author and handed to the examiners on a separate occasion. Only the author knew students' identities. The examiners were at no time aware of which examination papers or platforms belonged to which arm of the study, thus avoiding examiner bias (Newble & Paget 1996). The examiners handed the marked papers and platforms back to the author for compilation of a data bank. The examiners were not involved in the development of this PSWM program nor did they have any contact with the students during the testing period. Both examiners were initially taken through mock runs of marking papers and platforms in order to ensure consensus in the marking procedure (Newble,& Paget 1996). When consistency was achieved, they were allowed to mark the students' papers and platforms. The author at no time audited their assessments after the initial training period.

2.3.6 Statistical Analysis of Results

To assess for homogeneity between the computer and control groups, the categorised variables ie. gender, English as first language and clinical term during testing period, were analysed using Chi-square test with Program 4F, 'Two-way and multi-frequency tables', from the BMDP Statistical Software Package (Dixon 1993). The continuous variable of age, was analysed using t-Test with Program 3D, 't-Tests', from the BMDP Statistical Software Package (Dixon 1993). Comparisons of theoretical knowledge and practical skill acquisition were made between the computer and control groups by using Repeated Measures Analysis of Variance with Program 5V, ' Unbalanced repeated measures AOV', from the BMDP Statistical Software Package (Dixon 1993). To compare theoretical knowledge and practical skills end-points between the 4^{th} year control and 6^{th} computer groups, asymptotic Z-scores were used. These were calculated by comparing the difference in estimated means referenced to the standard error of a difference ie.

(4^{th} yr mean - 6^{th} yr mean) divided by (4^{th} yr S.E.^{2} + 6^{th} yr S.E.^{2})square root.

Only p-values of less than or equal to 0.01 were considered statistically significant on the recommendation of Mr Phillip Leppard BA (Hons, Stats), statistical consultant, Department of Statistics, The University of Adelaide, who also did all the statistical analyses. A p-value of less than 0.01 rather than 0.05 was chosen to make a more stringent assessment of outcome. Our interest lay with confidently identifying significant differences in learning outcomes between the groups which received the PSWM and those which did not.

Results are presented as real figures and not as a percentage of the maximum possible test result. The tests were structured to assess the students' ability to learn from the PSWM program material that was considered important to an independent medical practitioner. It was not structured to allow them to attain a 50% pass mark. Percentage scores were therefore not considered to be important.

CHAPTER THREE

RESULTS

3.1 INTRODUCTION TO RESULTS

3.1.1 Structure of Results Section

The presentation of results is sub-divided into three sections:

1. Population variables: assessment of inter-group homogeneity
2. Comparisons of learning between computer and control groups
3. Assessment of retention of newly learnt material

Results are detailed in the relevant tables and illustrated in the graphs. The Z and P values that are not applicable are listed as 'na' in the tables. This notation does not mean not available. Six of the eighty students did not do their final tests, however the statistical programs were able to account for missing values.

3.2 POPULATION VARIABLES WITHIN THE STUDY

3.2.1 Assessment of Categorised Variables Between Control and Computer Groups

The characteristics of both the computer and control groups for gender, English being the first language, and the students term commitments, were examined for homogeneity using Chi-square tests. No significant differences were found between the control and computer groups within both the 4th year and 6th year students regarding these variables. The single possible exception was the 4th year control group that had more students doing their surgical term during the testing period than the computer group. The p-value for this difference was 0.036, which did not reach statistical significance according to our criteria. Tables 3.1 to 3.6 show the data relating to the students' gender, English as first language and clinical attachment terms.

Table 3.1:

Gender distribution, a variable between the control and computer group 4th year students.

Gender	*Control group*	*Computer group*	*Total*
male	7	8	15
female	13	12	25
Total	20	20	40

Pearsons Chi-square value = 0.11, D.F.=1, p-value = 0.74

Yates corrected Chi-square value = 0.01, D.F. = 1, p-value = 0.999

Table 3.2:

Gender distribution, a variable between the control and computer group 6th year students.

Gender	*Control group*	*Computer group*	*Total*
male	14	11	25
female	6	9	15
Total	20	20	40

Pearsons Chi-square value = 0.96, D.F. = 1, p-value = 0.33

Yates corrected Chi-square value = 0.43, D.F. = 1, p-value = 0.51

Table 3.3:

English as first language, a variable between the control and computer group 4th year students.

English as first language	*Control group*	*Computer group*	*Total*
no	4	4	8
yes	16	16	32
Total	20	20	40

Chi-square test not relevant, groups equally matched.

Table 3.4:

English as first language, a variable between the control and computer group 6th year students.

English as first language	*Control group*	*Computer group*	*Total*
no	8	8	16
yes	12	12	24
Total	20	20	40

Chi-square test not relevant, groups equally matched.

Table 3.5:

Clinical attachment during the testing period, a variable between the control and computer group 4th year students.

Clinical Term	*Control Group*	*Computer Group*	*Total*
surgery	10	5	15
medicine	6	14	20
other	4	1	5
Total	20	20	40

Pearson Chi-square value = 6.67, D.F. = 2, p-value = 0.036

Table 3.6:

Clinical attachment during the testing period, a variable between the control and computer group 6th year students.

Clinical Term	*Control Group*	*Computer Group*	*Total*
surgery	9	8	17
medicine	10	8	18
other	1	4	5
Total	20	20	40

Pearson Chi-square value = 2.08, D.F. = 2, p-value = 0.35

3.2.2 Assessment of Continuous Variables Between Control and Computer Groups

Student age was a continuous variable and therefore tested by t-Test. No significant difference was found in the mean ages between the computer and control groups within the 4th and 6th year groups. Tables 3.7 and 3.8 show the relevant data.

Table 3.7:

Age as a variable between the control and computer group 4th year students.

	Control group	*Computer group*
mean age	21.30	21.65
S.E.M.	0.42	0.36

Pooled t-Test value = 0.63, D.F. = 38, p-value = 0.54

Table 3.8:

Age as a variable between the control and computer group 6th year students.

	Control group	*Computer group*
mean age	23.30	25.90
S.E.M.	0.33	1.17

Pooled t-Test value = 2.24, D.F. = 38, p-value = 0.03

3.3 COMPARISONS OF THEORETICAL KNOWLEDGE AND PRACTICAL SKILLS LEARNING BETWEEN THE CONTROL AND COMPUTER GROUPS

3.3.1 Strategy for Comparing the Computer and Control Groups Test Results

The computer groups did three lots of tests: pre-test, post-test1 (immediately after exposure to PSWM program) and post-test 2 (one month later). Pre-test was a base-line test. Post-test 1 was used to asses "short-term retention" of the material newly learnt from PSWM, hence was given approximately one hour after the base-line pre-test. Post-test 2 was used to asses "long-term retention", hence was done one month later. The control groups only did two tests: pre-test and post-test 2. They did not do post-test 1, to retest them would have meant asking them to take a repeat test one hour after their pre-test without having had the benefit of any teaching in the interim, therefore it would not have served any purpose. Post-test 2 was given to the control groups a month latter to asses them for new skills and knowledge that they may have acquired during their clinical attachments.

In comparing the computer and control groups, only pre-test and post-test 2 results were used, as these were the tests that they had in common.

3.3.2 Comparisons of Theoretical Knowledge Learning Between 4th year Computer and Control Groups

Repeated Measures Analysis of Variance was used to compare the changes between the pre-test and post-test 2 measurements of theoretical knowledge made on individuals across the 4th year groups. The Analysis of Variance Table (Table 3.9) shows there to be a significant difference in the group and time effects ($p<0.001$) between the 4th year control and computer groups in regard to their learning of skin wound management theories.

Table 3.9:

The Analysis of Variance Table of 4th year's theoretical knowledge scores

	DF	*Chi-square*	*P-value*
Group	1	3.55	0.060
Time	1	71.29	< 0.001
G.T	1	40.14	< 0.001

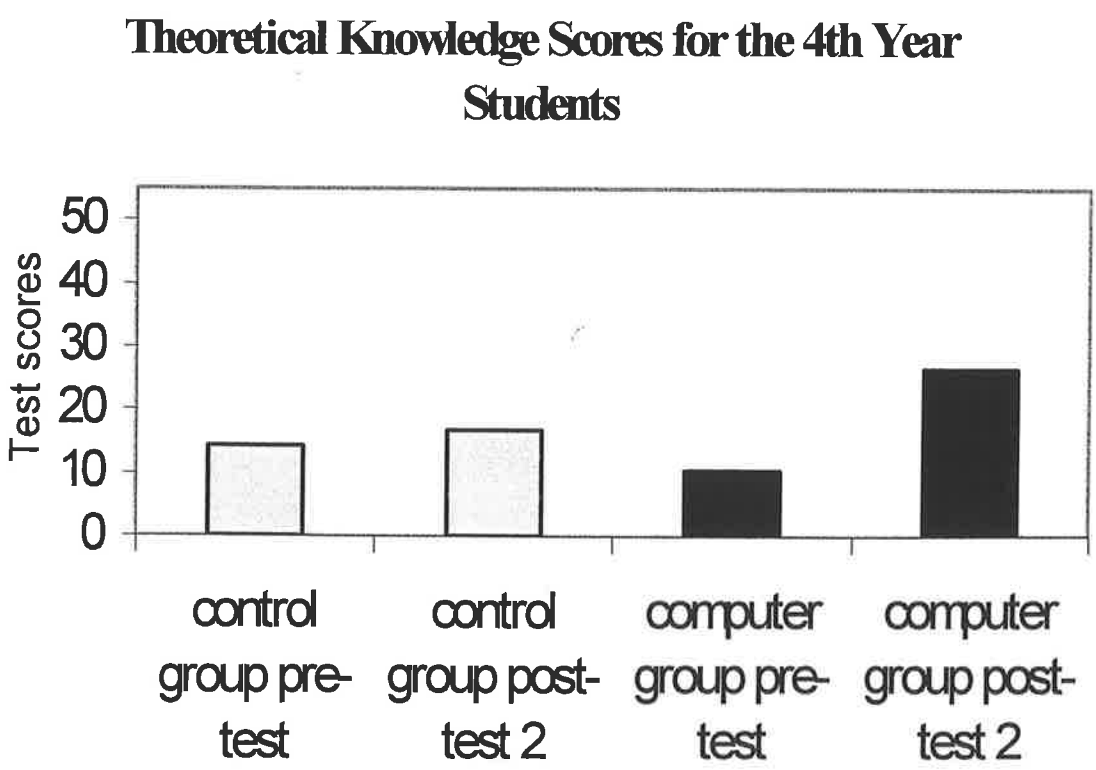
The linear model forming the basis of this analysis was used to estimate the mean effects and this is shown in Table 3.10 . The control group achieved mean pre-test and post-test 2 scores of 14.3 and 16.6, respectively (see rows a,b in table 3.10). The computer group achieved mean pre-test and post-test 2 scores of 10.5 and 26.5 respectively (rows c-d). The control group had a higher baseline pre-test score than the computer group, 14.3 vs 10.5, p=0.04, however this did not reach statistical significance (row e). The 4th year control group did not significantly improve in their theoretical knowledge during the one month, between their pre-test and post-test 2, 14.3 vs 16.6 respectively , p=ns (row f). However the 4th year computer group showed a marked improvement in their theoretical knowledge scores between their pre-test and post-test 2, at one month, 10.5 vs 26.5 respectively, p-value < 0.001 (row g). Furthermore the computer group 4th years did significantly better in their final test (post-test 2) than the control group 4th years, 26.5 vs 16.6, respectively, p-value < 0.001 (row h). Figure 3.1 graphically illustrates these findings. Note that the maximum possible score is 55 points.

Table 3.10:

Inter-group comparison of theoretical knowledge test scores between control and computer group 4th year

4th Year Theory tests	*Marks*	*S.E.*	*Z-score*	*P-value*
a) control group pre-test results	14.35	1.33	na	na
b) control group pre-test 2 results	16.63	1.44	na	na
c) computer group pre-test results	10.50	1.34	na	na
d) computer group post-test 2 results	26.50	1.34	na	na
e) control vs computer group pre-test	+3.85	1.89	2.03	0.042
f) control group pre-test vs post-test 2	+2.28	1.57	1.49	0.157
g) computer group pre-test vs post-test 2	+16.00	1.49	10.76	< 0.001
h) control vs computer group post-test 2	- 9.87	1.96	5.02	< 0.001

Figure 3.1



3.3.3 Comparisons of Theoretical Knowledge Learning Between 6th year Computer and Control Groups

The Analysis of Variance Table (Table 3.11) shows there to be a significant difference in the group and time effects ($p<0.001$) between the 6th year control and computer groups in regard to their learning of skin wound management theories.

Table 3.11:

The Analysis of Variance Table of 6th years theoretical knowledge scores

	DF	*Chi-square*	*P-value*
Group	1	4.47	0.035
Time	1	49.35	< 0.001
G.T	1	50.95	< 0.001

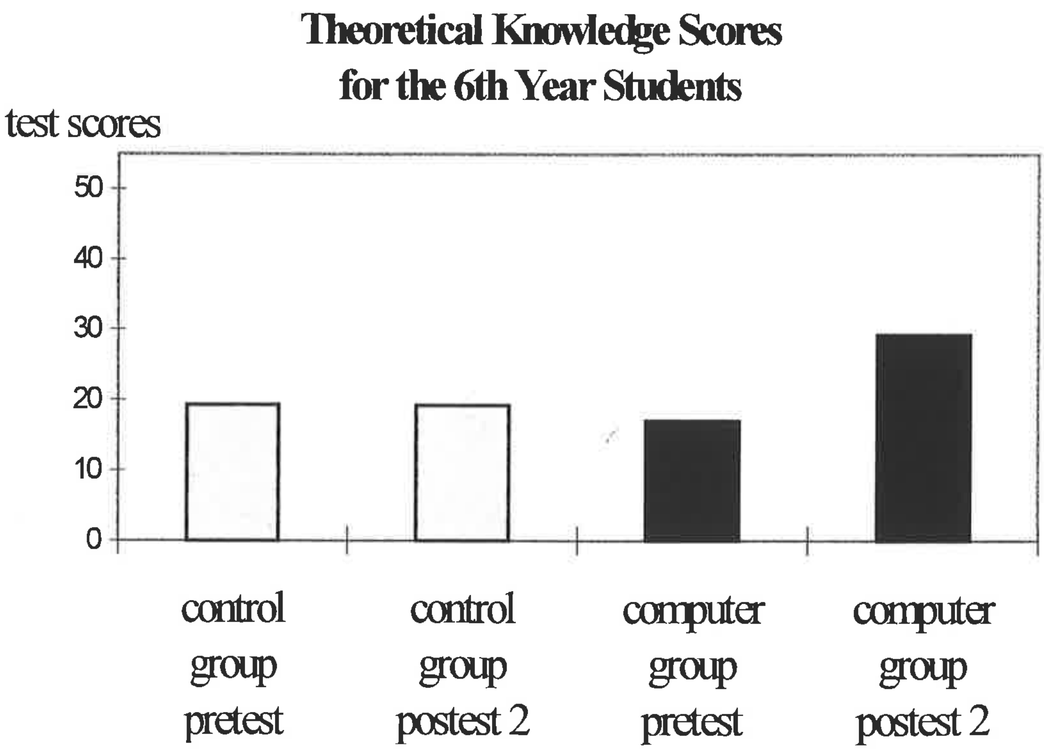
The linear model forming the basis of this analysis was used to estimate the mean effects and this is shown in Table 3.12. The control group achieved mean pre-test and post-test 2 scores of 19.2 and 19.1, respectively (rows a,b). The treatment group achieved mean pre-test and post-test 2 scores of 16.9 and 29.1, respectively (rows c,d). There was no significant difference between the 6th year control and computer groups baseline pre-test scores on theoretical knowledge, 19.2 vs 16.9 respectively, p=ns (row e). The 6th year control group did not significantly improve in their theoretical knowledge during the one month between the pre-test and post-test 2, 19.2 vs 19.1 respectively. p=ns (row f). However the 6th year computer group showed a marked improvement in their theoretical knowledge scores between their pre-test and post-test 2, 16.9 vs 29.1 respectively, p-value < 0.001 (row g). Furthermore the computer group 6th years did significantly better in their final test (post-test 2) than the control group 6th years, 29.1 vs 19.1 respectively, p-value < 0.001 (row h). Figure 3.2 graphically illustrates these findings. Note the maximum possible score for the theory test is 55 points.

Table 3.12:

Inter-group comparison of theoretical knowledge test scores between control and computer group 6th year students

6th Year Theory tests	*Marks*	*S.E.*	*Z-score*	*P-value*
a) control group pre-test results	19.28	1.41	na	na
b) control group post-test 2 results	19.18	1.45	na	na
c) computer group pre-test results	16.98	1.41	na	na
d) computer group post-test 2 results	29.18	1.43	na	na
e) control vs computer group pre-test	+2.30	1.99	1.16	0.248
f) control group pre-test vs post-test 2	- 0.10	1.23	0.08	0.937
g) computer group pre-test vs post-test 2	+12.20	1.25	10.13	< 0.001
h) control vs computer group post-test 2	-10.00	2.04	4.91	< 0.001

Figure 3.2



3.3.4 Comparisons of Practical Skills Learning Between the 4th year Computer and Control Groups

The Analysis of Variance Table (Table 3.13) shows there to be a significant difference in the group and time effects ($p<0.001$) between the 4th year control and computer groups in regard to their learning of practical skills, namely suturing and tying knots.

Table 3.13:

The Analysis of Variance Table of 4th years practical skills scores

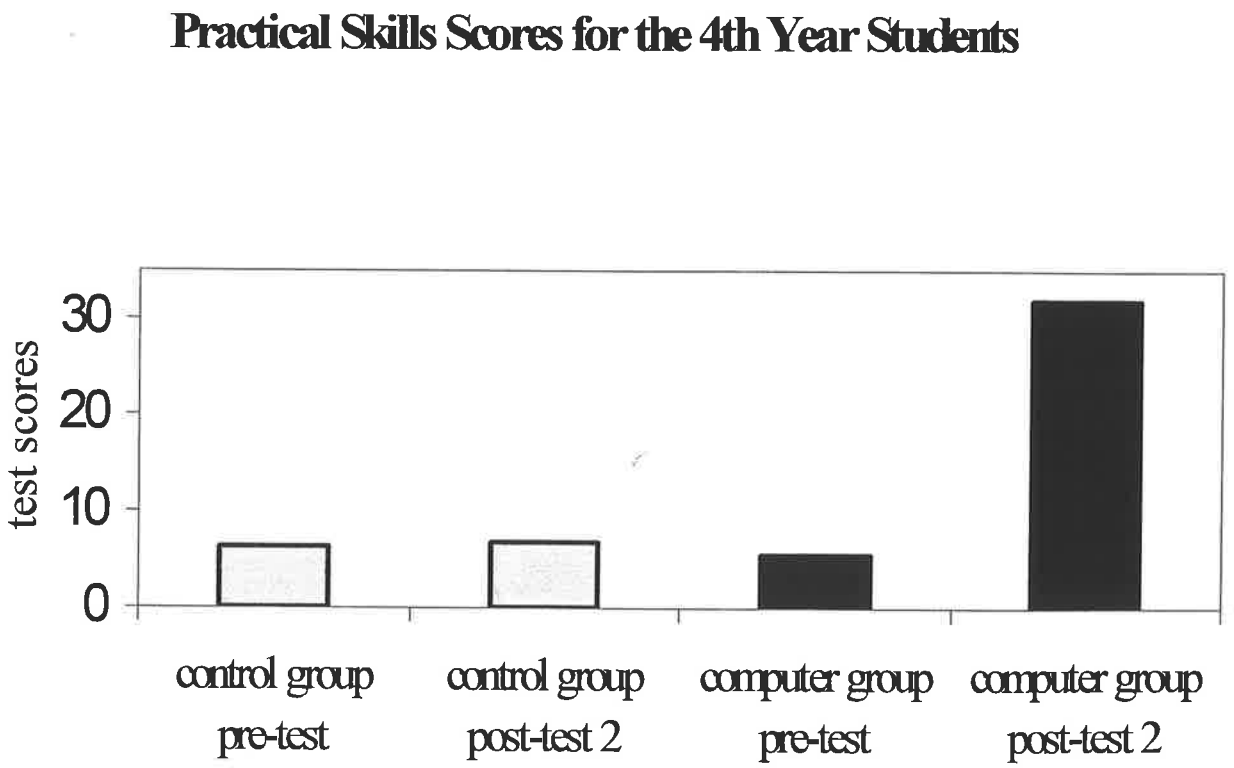
	DF	*Chi-square*	*P-value*
Group	1	79.42	< 0.001
Time	1	222.33	< 0.001
G.T	1	203.48	< 0.001

The linear model forming the basis of this analysis was used to estimate the mean effects and this is shown in Table 3.14. The control group achieved mean pre-test and post-test 2 scores of 6.2 and 6.8, respectively (rows a,b). The computer group achieved mean pre-test and post-test 2 scores of 5.5 and 31.9, respectively (rows c,d). There was no significant difference between the 4th year control and computer groups baseline pre-test scores on practical skills competence, 6.2 vs 5.5 respectively, p=ns (row e). Additionally, the 4th year control group did not improve significantly in their practical skills during the one month between the pre-test and post-test 2, 6.2 vs 6.8 respectively, p=ns (row f). However the computer group 4th years showed a marked improvement in their practical skills scores between their pre-test and post-test 2, 5.5 vs 31.9 respectively, p-value < 0.001 (row g). Furthermore the computer group 4th years did significantly better in their final test (post-test 2) than the control group 4th years, 31.9 vs 6.8 respectively, $p < 0.001$ (row h). Figure 3.3 graphically illustrates these findings. Note the maximum possible score for the OSCE's is 39 points.

Table 3.14: Inter-group comparison of practical skills test scores between control and computer group 4th year

4th Year OSCE tests	*Marks*	*S.E.*	*Z-score*	*P-value*
a) control group pre-test results	6.23	1.14	na	na
b) control group post-test 2 results	6.81	1.22	na	na
c) computer group pre-test results	5.50	1.14	na	na
d) computer group post-test 2 results	31.90	1.14	na	na
e) control vs computer group pre-test	- 0.73	1.61	0.45	0.652
f) control group pre-test vs post-test 2	+0.58	1.32	0.44	0.657
g) computer group pre-test vs post-test 2	+26.40	1.24	21.26	< 0.001
h) control vs computer group post-test 2	- 25.09	1.67	15.04	< 0.001

Figure 3.3



3.3.5 Comparisons of Practical Skills Learning Between the 6th year Computer and Control Groups

The Analysis of Variance Table (Table 3.15) shows there to be a significant difference in the group and time effects ($p<0.001$) between the 6th year control and computer groups in regard to their learning of skin wound practical skills, namely suturing and tying knots.

Table 3.15:

The Analysis of Variance Table of 6th years practical skills scores

	DF	*Chi-square*	*P-value*
Group	1	4.80	0.028
Time	1	79.52	< 0.001
G.T	1	15.35	< 0.001

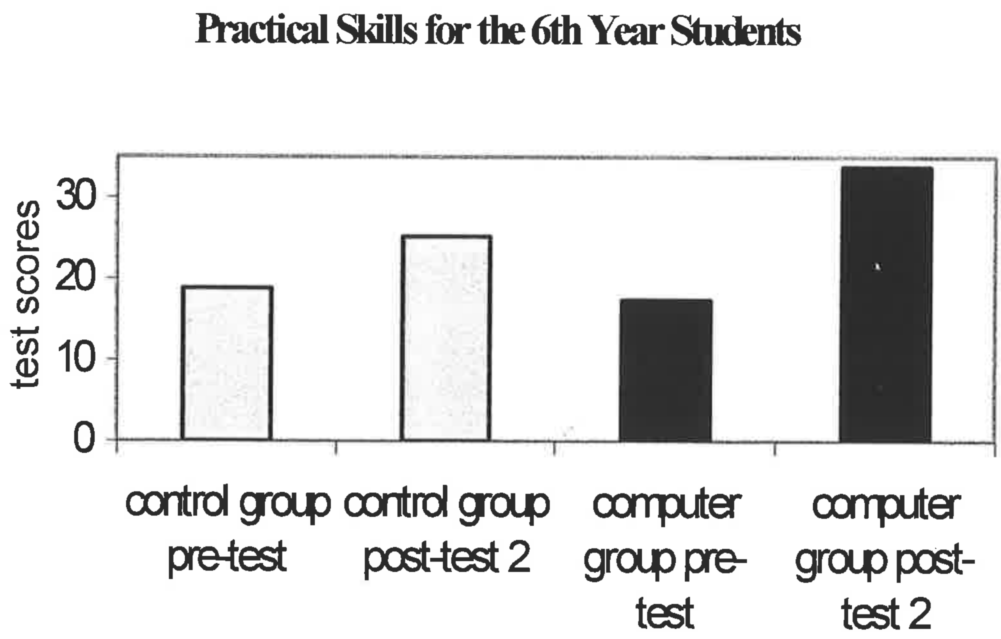
The linear model forming the basis of this analysis was used to estimate the mean effects and this is shown in Table 3.16. The control group achieved mean pre-test and post-test 2 scores of 18.8 and 25.2 respectively (rows a,b). The computer group achieved mean pre-test and post-test 2 scores of 17.4 and 33.7, respectively (rows c,d). There was no significant difference between the 6th year control and computer groups' baseline pre-test scores on practical skills competence, 18.8 vs 17.4 respectively, p=ns (row e). Both the 6th year control and computer groups significantly improved their practical skills during the one month between the pre-test and post-test 2. The control group's pre-test and post-test 2 results were 18.8 vs 25.1 respectively, $p<0.001$ (rows f). The computer group achieved 17.4 vs 33.7 respectively, $p<0.001$ (row g). However the computer group 6th years achieved significantly better results in their final tests (post-test 2) than the control group 6th years, 33.7 vs 25.1 respectively, p-value < 0.001 (row h). Figure 3.4 graphically illustrates these findings. Note the maximum possible score for the OSCE's is 39 points.

Table 3.16:

Inter-group comparison of practical skills test scores between control and computer group 6th year

6^{th} *Year OSCE tests*	*Marks*	*S.E.*	*Z-score*	*P-value*
a) control group pre-test results	18.83	1.44	na	na
b) control group post-test 2 results	25.20	1.51	na	na
c) computer group pre-test results	17.43	1.44	na	na
d) computer group post-test 2 results	33.78	1.48	na	na
e) control vs computer group pre-test	-1.40	2.04	0.69	0.492
f) control group pre-test vs post-test 2	+6.37	1.82	3.50	< 0.001
g) computer group pre-test vs post-test 2	+16.36	1.79	9.16	< 0.001
h) control vs computer group post-test 2	-8.58	2.11	4.06	< 0.001

Figure 3.4



3.3.6 Comparison of Theoretical Knowledge and Practical Skills End-Points Between 4th Year Computer and 6th Year Control Groups

Asymptotic Z-scores were used to compare the end-points between the 4th year computer group and the 6th year control group. It was of interest to find that the 4th year computer group actually scored significantly higher post-test 2 results than the 6th year control group, for both theoretical knowledge (26.5 vs 19.1, p<0.001) and practical skills (31.9 vs 25.1, p<0.001), even though the 4th year's started at a much lower level. Table 3.17 compares their theory scores while table 3.18 compares their practical skills scores.

Table 3.17:

Inter-group comparison of theoretical knowledge post-test 2 results between 4th year computer and 6th year control groups.

	4th year Computer group	*6th year Control group*
Post-test 2 results for theory	26.5	19.2
S.E.	1.34	1.45

Z score = 3.71. p-value = < 0.001

Table 3.18:

Inter-group comparison of practical skills post-test 2 results between 4th year computer and 6th year control groups.

	4th year Computer group	*6th year Control group*
Post-test 2 results for motor skills	31.9	25.2
S.E.	1.14	1.51

Z score = 3.54, p-value = < 0.001

3.4 ASSESSMENT OF STUDENTS' RETENTION OF NEWLY LEARNT MATERIAL FOLLOWING EXPOSURE TO PSWM PROGRAM

3.4.1 Assessment of Theoretical Knowledge Retention by 4th Year Students

Repeated Measures Analysis of Variance was used to compare the 4th year computer group's pre-test , post-test 1 (done immediately after exposure to PSWM) and post-test 2 (done 1 month after PSWM exposure) measurements of theoretical knowledge. The Analysis of Variance Table (Table 3.19) shows there to be a significant difference in the time effects ($p<0.001$) between the test results achieved by the 4th year computer group students.

Table 3.19:

The Analysis of Variance Table for the 4th year computer group's theoretical knowledge scores

	DF	*Chi-square*	*P-value*
Time	2	170.03	< 0.001

The linear model forming the basis of this analysis was used to estimate the mean effects and this is shown in table 3.20 . The 4th year students' mean pre-test, post-test 1 and post-test 2 scores were 10.5, 29.9 and 26.5, respectively (rows a-c). They had a significant improvement in theoretical knowledge score between the pre-test and post-test 1, 10.5 vs 29.9 respectively, $p<0.001$ (row d). This value was used as a gauge of immediate retention of new learning material. However there was a tendency towards reduction of theoretical knowledge scores, in the intervening month between post-test 1 and post-test 2, 29.9 vs 26.5 respectively, $p=0.031$, but this did not reach statistical significance (row f). This difference was used to gauge the rate of loss of newly learnt material during the month following exposure to PSWM.

Table 3.20:

Intra-group comparison of theoretical knowledge results within the 4th year computer group

Theory test	*Test Results*	*S.E.*	*Z-score*	*P-value*
a) pre-test	10.50	1.61	na	na
b) post-test 1	29.93	1.61	na	na
c) post-test 2	26.50	1.61	na	na
d) pre-test vs post-test 1	+19.43	1.59	12.21	< 0.001
e) pre-test vs post-test 2	+16.00	1.59	10.06	< 0.001
f) post-test 1 vs post-test 2	- 3.43	1.59	2.15	0.031

3.4.2 Assessment of Theoretical Knowledge Retention by 6th Year Students

The Analysis of Variance Table (Table 3.21) shows there to be a significant difference in time effects ($p<0.001$) between the theoretical knowledge test results achieved by the 6th year computer group students.

Table 3.21:

The Analysis of Variance Table for the 6th year computer group's theoretical knowledge scores

	DF	*Chi-square*	*P-value*
Time	2	256.48	< 0.001

The linear model forming the basis of this analysis was used to estimate the mean effects and this is shown in table 3.22. The 6th year students achieved mean pre-test, post-test 1 and post-test 2 scores of 16.9, 34.5, and 29.0, respectively (rows a-c). They had a significant improvement in theoretical knowledge score between the pre-test and post-test 1, 16.9 vs 34.5 respectively, $p<0.001$ (row d). This is used as a gauge of immediate retention of new learning material. There was a significant reduction of theoretical knowledge score, in the intervening month between post-test 1 and post-test 2 scores, 34.5 vs 29.0 respectively, p<0.001 (row f). This difference was used to gauge the attrition rate of newly learnt material during the month following exposure to PSWM.

Table 3.22:

Intra-group comparison of theoretical knowledge results within the 6th year computer group

Theory test	*Test Results*	*S.E.*	*Z-score*	*P-value*
a) pre-test	16.98	1.50	na	na
b) post-test 1	34.50	1.50	na	na
c) post-test 2	29.09	1.50	na	na
d) pre-test vs post-test 1	+17.53	1.12	15.66	< 0.001
e) pre-test vs post-test 2	+12.12	1.14	10.63	< 0.001
f) post-test 1 vs post-test 2	- 5.41	1.14	4.74	< 0.001

3.4.3 Assessment of Practical Skills Retention by 4th Year Students

Analysis of Variance Table (Table 3.23) shows there to be a significant difference in time effects (p<0.001) between the practical skills test results achieved by the 4th year computer group students.

Table 3.23:

The Analysis of Variance Table for the 4th year computer group's practical skills scores.

	DF	*Chi-square*	*P-value*
Time	2	464.54	< 0.001

The linear model forming the basis of this analysis was used to estimate the mean effects and this is shown in table 3.24 . The 4th year students mean practical skills pre-test, post-test 1 and post-test 2 scores were 5.5, 31.7 and 31.9, respectively (rows a-c). They had a significant improvement in practical skills score between the pre-test and post-test 1, 5.5 vs 31.7 respectively, p<0.001 (row d). This is used as a gauge of immediate retention of new learning material. There was no significant reduction of practical skills score, in the intervening month between post-test 1 and post-test 2, 31.7 vs 31.9, p=0.9 (row f).

Table 3.24:

Intra-group comparison of practical skills results within the 4th year computer group

OSCE test	*Test Results*	*S.E.*	*Z-score*	*P-value*
a) pre-test	5.50	1.14	na	na
b) post-test 1	31.75	1.14	na	na
c) post-test 2	31.90	1.14	na	na
d) pre-test vs post-test 1	+26.25	1.41	18.61	< 0.001
e) pre-test vs post-test 2	+26.40	1.41	18.72	< 0.001
f) post-test 1 vs post-test 2	+0.15	1.41	0.11	0.915

3.4.4 Assessment of Practical Skills Retention by 6th Year Students

The Analysis of Variance Table (Table 3.25) shows there to be a significant difference in time effects ($p<0.001$) between the practical skills test results achieved by the 6th year computer group students.

Table 3.25:

The Analysis of Variance Table for the 6th year computer group's practical skills scores.

	DF	*Chi-square*	*P-value*
Time	2	122.44	< 0.001

The linear model forming the basis of this analysis was used to estimate the mean effects and this is shown in table 3.26. The 6th year students' mean pre-test, post-test 1 and post-test 2 scores were 17.4, 35.2 and 33.7, respectively (rows a-c). They had a significant improvement in practical skills score between the pre-test and post-test 1, 17.4 vs 35.2 respectively, $p<0.001$ (row d). This is used as a gauge of immediate retention of new learning material. There was no significant reduction of theoretical knowledge scores, in the intervening month between post-test 1 and post-test 2, 35.2 vs 33.7 respectively, p=0.4 (row f).

Table 3.26:

Intra-group comparison of practical skills results within the 6th year computer group

OSCE test	*Test Results*	*S.E.*	*Z-score*	*P-value*
a) pre-test	17.43	1.34	na	na
b) post-test 1	35.23	1.34	na	na
c) post-test 2	33.72	1.37	na	na
d) pre-test vs post-test 1	+17.80	1.78	10.01	< 0.001
e) pre-test vs post-test 2	+16.30	1.80	9.04	< 0.001
f) post-test 1 vs post-test 2	- 1.50	1.80	0.83	0.405

CHAPTER FOUR

DISCUSSION OF RESULTS AND FUTURE APPLICATION

4.1 DISCUSSION OF RESULTS

4.1.1 Homogeneity of Study Groups

Both the fourth and sixth year students, computer and control groups were well matched for the variables of age, gender, language skills and clinical attachments during the period of investigations. The one potential exception was that of the fourth year control group which had more students with exposure to surgery during the period of investigation than the treatment group. This difference did not reach statistical significance ($p = 0.036$). In any event, this potential bias was in the interests of the study as it favoured the control, rather than the treatment group. Students are more likely to receive practical skills training on skin wound management during surgical attachments than during medical attachments.

The computer and control groups for both the fourth and sixth year students were also well matched for their baseline (pre-test) scores of theoretical knowledge and practical motor skills. No significant differences were found between the pre-test scores.

In summary, the computer and control groups appeared to be well matched for population variables and baselines of theoretical knowledge and practical skills competence. Therefore, it is reasonable to presume that later divergence in test scores, between the computer and control groups is attributable to the educational input of the PSWM program.

4.1.2 PSWM as a Primary Teaching Tool

At The University of Adelaide, fourth year medical students receive no scheduled training on practical skin wound management during this year of their education. This is confirmed by the findings of this study that the control group fourth year students made no significant progress in either their theoretical knowledge, nor practical skills competency scores, during the period of investigation. In contrast, the computer group was exposed to skin wound management specific teaching, using the PSWM program. For them, this acted as a primary teaching tool on this subject. Subsequently the computer group made substantial and statistically significant improvements in both their theoretical knowledge and practical skills competency scores. The control fourth year group only improved their mean theoretical knowledge score by 4% , (ie. 2 extra marks out of 55), and their practical skills by 0.3%, (ie. 0.2 extra marks out of 39). However the computer groups significantly improved their theoretical knowledge by 29% (ie. 16 extra marks out of 55), and their practical skills competence score by 68% (ie. 26.4 extra marks out of 39). Remembering that the computer group only received a one-hour exposure to PSWM, these results indicate that PSWM is a highly effective undergraduate 'stand-alone', primary teaching tool both for theoretical knowledge and practical skills. This is consistent with a number of earlier studies (see section 1.3.5.i) which found MMs to be as effective as traditional teaching methods. However, as the 4th year control students in this study did not receive any other scheduled training on skin wound management, we can not compare PSWM to another traditional teaching method. All we can say that by itself, it helped to significantly improve the theoretical knowledge and clinical skills of the 4th year computer group students. This study could have been made stronger by adding a third arm, in which a third group of 4th year students were given a single one hour tutorial on the subjects covered by PSWM and then compared outcomes. Doing so would have permitted to quantify the effectiveness of PSWM compared to group tutorial compared to no teaching. This is a shortcoming in this study, which is acknowledged by the investigator.

4.1.3 PSWM as a Supplementary Teaching Tool

Sixth year medical students receive scheduled practical skills workshop and some tutorials on skin wound management and wound healing. Additionally, they receive clinical exposure to the management of skin wounds during both their surgical attachments (e.g. operations, trauma) and medical attachments (eg. pressure ulcers, venous leg ulcers). For these reasons, the addition of the teaching module PSWM to their training was considered to be a supplementary teaching tool. However, the investigator acknowledges that as the students were volunteers, doing different clinical attachments, therefore it was not possible to standardise the skin wound management teaching they received as past of their curricular, during the testing period. This is a weakness of the study, which was not possible to avoid, as the investigator could not control when the students volunteered, he was obliged to accept them as they became available. However it was encouraging to note that there was no significant difference in the clinical attachments between the control and computer groups, suggesting that there would have been homogeneity in the curricular teaching received by both the control and computer groups. Therefore the investigator believes that it is defendable to consider the addition of PSWM to the computer group, as a supplementary teaching tool.

The results for the control group 6th years indicate that overall, they did in, fact, receive a significant amount of scheduled teaching while part of this study. Their mean score for practical skills competence significantly increased by 16% (ie. 6.3 extra marks out of 39). However, it is of some interest to note that their theoretical knowledge of practical skin wound management did not significantly improve. Their post-test 2 score was only 4% higher (ie. 2.2 extra marks out of 55 points). This finding is consistent with the impression of the staff of the Department of Plastic Surgery that students, and even junior post-graduate trainees, have a deficiency in their understanding of the practical management of skin wounds. The computer group achieved more significant improvements in both their theoretical knowledge and practical skills competence scores. Their mean theoretical knowledge score significantly increased 22% (ie. 12.3 extra marks out of 55). There was also a significant improvement in their mean practical skills competence scores which significantly increased by 42% (ie. 16.4 extra marks out of 39). The computer group showed a significantly greater increase of practical skills above that of the control group, 16.4 points (42%) vs 7 points (16%). The computer group also scored significantly higher end-points for practical skills than the control group, their post test 2 results were 33.8 versus 25.2, a difference of 8.6 points in favour of the computer group. This indicates a statistically significant, supplementary gain in practical skills by the computer group over the control group. This is consistent with a number of earlier studies (see section 1.3.5.iii) which found supplementary MMs to be effective teaching methods. In summary, the above findings indicate that the PSWM program is an effective supplementary teaching tool for both theoretical knowledge and practical skills.

4.1.4 Time Effective Learning with PSWM

The findings indicate that the PSWM program was able, after a single hour of exposure, to bridge the gap in both skin wound management theoretical knowledge and practical skills, between the 4^{th} and 6^{th} year students. It found that the computer group 4^{th} years actually scored higher post-test 2 results for both theoretical knowledge and practical skills competence, than the 6^{th} year control group. This is all the more impressive when one notes that the 4^{th} years started with significantly lower base-line scores than the control group 6^{th} years and they only received one hour of exposure to PSWM. The post test 2 scores for theoretical knowledge, between the fourth and six years were 26.5 versus 19.2 ($p < 0.001$) and for practical skills they were 31.9 versus 25.2 ($p < 0.001$). The improvement in recall of large amounts of information after only a very brief exposure to an interesting learning experience is well recognised (Vicente and Wang 1998). The findings of this study were very encouraging and suggested at least two things:

- Firstly that the treatment group's single hour of exposure to the PSWM program was very time effective.
- Secondly, that students are able to make greater progress in learning than is currently the case, so long as they are provided with better quality learning experiences. Developing media which provide time effective self-study is in keeping with the recommendations of both the GMC (1993) and AAMC (GPEP 1984) for implementing educational strategies for the 21^{st} century.

4.1.5 Retention of Newly Learnt Material from PSWM

Memory of newly acquired information deteriorates over time unless periodically reinforced. It was interesting to find that there was only loss of new theoretical knowledge material during the one-month testing period. The newly learnt practical skills were retained during this period without significant loss. The results show that the 4th and 6th year students had a tendency towards forgetting newly learnt theoretical knowledge between post test 1 (given immediately after PSWM exposure) and post test 2 (given 1 month after PSWM exposure). The 4th years showed a decrease of 11%, (p-value was 0.03), which suggested a tendency but it did not attain statistical significance. The 6th years showed a decrease of 16% ($p < 0.001$) which was statistically significant. It is not possible to adequately explain why the 6th years displayed a greater attrition rate of newly acquired theoretical knowledge compared to the 4th year students. It was the investigator's impression that the 4th year students were very eager to acquire new clinical experiences, whereas the 6th year students were more concerned with material specifically relevant to their forthcoming final examinations. The higher attrition rate amongst the 6th years may also reflect the greater overall workload that they had compared to the 4th year students.

However the situation was quite different for the retention of newly acquired practical skills. In this case, neither the 4th nor the 6th years showed any significant decrease with time. The 4th year score went up by 0.4% (p=NS) while the 6th year score went down by 4%(p=NS).

There are two conclusions which may be drawn from these findings:

- The Multimedia application entitled PSWM is effective in encouraging long term retention of newly acquired practical skills.
- Newly acquired information, especially theoretical knowledge, probably needs reinforcement to enhance its retention. It appears that the first revision should occur within the first month.

4.1.6 The Uniqueness of This Study

There have been a number of comparative studies in the past which have shown multi-media applications to be at least equal to traditional teaching methods for facilitating the learning of theoretical knowledge and clinical skills competence. However there were no reports found in the literature, of any studies assessing the effectiveness of a MM for teaching practical skin wound management. Additionally, there are no reported studies assessing the ability of MM to facilitate the learning of practical motor skills like suturing and knot tying.

These issues attest to the uniqueness of this study because:

- It assesses the effectiveness of a MM for teaching skin wound management, and
- It assesses the acquisition of practical skills like suturing and knot tying.

The findings of this study, as discussed in sections 4.1.2 and 4.1.3, have shown that the MM entitled PSWM is a highly effective medical undergraduate primary, as well as supplementary, teaching tool for both theoretical knowledge and practical motor skills in the field of skin wound management. That is to say, it was used as a "stand-alone" teaching tool with the 4th year students and as a "supplementary" teaching tool for the 6th year students i.e. added to their curricular as it was. No direct comparison was made between it and a well-defined traditional teaching experience, such as a small group tutorial. One would not expect a multimedia program to be able to compete with small tutorials run by an experienced, enthusiastic teacher. What multimedia programs do is "standardise" the teaching, and make learning experiences available to students at any time for self-motivated learning. Computer assisted learning is expected to increasingly contribute to and support, not compete with time-tested traditional teaching methods.

4.2 FUTURE APPLICATIONS

4.2.1 Future Testing of PSWM

The Department of Plastic and Reconstructive Surgery of the University of Adelaide, Department of Surgery, is committed to assessing PSWM as a continuing educational teaching tool for general practitioners. Moves to this effect are already under way and it is hoped that the follow-on study will be in place before the end of 1999. Concurrent with this, it is planned to make PSWM available to the public on CD-ROM in the near future.

4.2.2 Possible Factors Contributing to Success of PSWM

The success of PSWM for undergraduate medical education was probably enhanced by the simplicity of its multi-media format. The screen was kept uncluttered, avoiding any distracting ancillary aids, such as unnecessary buttons, graphics and hot words. Access to the different sections in each module was made very simple with the use of hypertext menus. The page layout used an economical combination of evidence-based text, supported by video, graphics and photographic images. Although this MM is based largely upon a didactic model of teaching, users are able to control the presentation of the images by reviewing them as desired. The users were able to halt, and repeatedly replay, segments of interest in video clips. This was very useful for learning the finer points of specific surgical manoeuvres, for example suturing. Additionally the users were provided with suturing and knot tying platforms in order to practice their skills while viewing them on-screen. This innovation enhances the CAL of clinical skills and would have contributed to the effectiveness of PSWM as clinical skills teaching tool.

4.2.3 The Future Evolution of Computer Assisted Learning: Virtual Reality

Currently MMs are the most popular methods for CAL, however it is expected that this will be superseded by virtual reality in the early years of the 21st century. Virtual reality is a highly interactive and dynamic form of simulation in which a computer generated world (virtual environment) can be entered into, and objects explored with visual, aural and touch sensors (Hoffman &Vu 1997). It is particularly useful for visual learning and especially complex topics like anatomy, molecular biology, procedural and surgical simulations. The programs are able to effect real time changes to the images in response to the participants actions. This new tool is already entering into medical undergraduate education in a number of institutions in the USA. One of the most advanced systems teaches emergency medicine at the Dartmouth-Hitchcock Medical Centre, Massachusetts. This prototype simulates lower limb injuries and allows trainees to perform assessment and debridement of deep penetrating wounds. The simulation provides real time changes of the simulated injured tissues in response to the trainees' interventions with simulated surgical instruments. At the current rate of development it is anticipated that by the year 2010, virtual reality will be capable of high fidelity simulations of open operations and will be an integral part of surgical training (Hoffman, Vu 1997). This permits the trainee to rehearse and refine operative procedures without putting a patient at risk and obviates the ethical concerns of experimentation on animal or human tissues.

4.2.4 The Emerging World Wide Electronic University

At the 1983 conference of the International Association of Universities, it was decided that the only way to effectively raise the educational standards in all countries, especially in the developing world, was "to create a global university system in which all higher education institutions share their resources" (Parker, Rossman 1992). It is expected that the evolving information technologies, especially the Internet, will make this goal possible. Distance learning is a well established phenomena and many universities in America, Europe and Australia are using telecourses to provide instruction to off-campus students. Students may now be at any location on the globe and still link-up to a program by means of landlines or radio transmitters. Additionally, many institutions are collaborating to produce on-line teaching programs. This pooling of resources benefits the students by expanding their access to quality resources. Additionally it may decrease the demands on the educators. Examples of this type of collaboration include, the INSURRECT undergraduate surgical teaching project in the U.K. and the European Mobility Program for University Students, for central European medical undergraduates and post-graduates.

With the current rate of progress, it is reasonable to predict that the first global electronic university should come into existence within the next decade. It may be envisaged that global regulating bodies will invite Departments or Units within particular universities, to provide teaching modules on their area of excellence. Expertise in the authoring of teaching modules with proven efficacy will be valued and sought out. The Department of Surgery, University of Adelaide, has such expertise and is well placed to become a recognised authority in the development of computer assisted learning in surgery.

BIBLIOGRAPHY

Ackerknecht EH (1982). A short history of medicine. Baltimore, The John Hopkins University Press, 1982.

Achenbach S. Alfke H. Klose KJ (1997). Teleteaching with CONRAD. From collected cases to interactive learning system. Radiologe. 37(4):299-304.

Allan DM. Walraven G. (1987). Issues in the adoption of a new educational technology. Computer Methods & Programs in Biomedicine. 25(2):103-109.

Andrew SM. Benbow EW (1997). Conversion of a traditional image archive into an image resource on compact disc. Journal of Clinical Pathology. 50(7):544-547.

Bolwell C (1993). Using computers as instructional technology in the pressure ulcer field. Decubitus. 6(4):20-25.

Bonner TN (1995). Becoming a physician: medical education in Britain, France, Germany and the United States, 1750-1945. New York, Oxford University Press, 1995.

Brebner EM. Brebner JA. Norman JN. Brown PA. Ruddick-Bracken H. Lanphear JH (1997). A pilot study in medical education using interactive television. Journal of Telemedicine and Telecare. 3 Suppl 1:10-12.

Bresnitz EA. Gracely EJ. Rubenstein HL (1992). A randomized trial to evaluate a computer-based learning program in occupational lung disease. Journal of Occupational Medicine. 34(4):422-427.

Bridges AJ. Reid JC. Cutts JH 3d. Hazelwood S. Sharp GC. Mitchell JA (1993). AI/LEARN/Rheumatology. A comparative study of computer-assisted instruction for rheumatology. Arthritis & Rheumatism. 36(5):577-580.

Byrne AJ. Hilton PJ. Lunn JN (1994). Basic simulations for anaesthetists. A pilot study of the ACCESS system. Anaesthesia. 49(5):376-381.

Calhoun PS, Fishman EK (1997). The GI proto-type electronic textbook for high school biology. Radiographics 17(1):203-211

Carlile S, Sefton AJ (1998). Health-care and the information age: implications for medical education. MJA 168: 340-343.

Channin DS (1995). A World Wide Web gateway to the radiological learning file. Academic Radiology. 2(12):1052-1055.

Chew FS. Smirniotopoulos JG (1995). Teaching skeletal radiology with use of computer-assisted instruction with interactive videodisc. Journal of Bone & Joint Surgery - American Volume. 77(7):1080-1086.

Chew FS. Stiles RS. Whitley JE (1994). Computer-assisted instruction with interactive videodisc versus textbook for teaching radiology. Academic Radiology. 1(4):326-331.

Chodorow S (1996). Educators must take the electronic revolution seriosly. Academic Med 71(3):221-226.

Coiera E (1998). Medical informatics meets medical education. MJA 168: 319-320.

DeAmicis PA (1997). Interactive videodisc instruction is an alternative method for learning and performing a critical nursing skill. Computers in Nursing. 15(3):155-158.

Coles C (1996). Developing medical education. Postgrad Med J 69:57-63.

Criley JM, Criley D, Zalace C (1996). Multimedia instruction of cardiac auscultation. Transactions of the American Clinical & Climatological Assoc 108:271-284.

Curry RH, Makoul G (1998). The evolution of courses in professional skills and perspectives for medical students. Academic Medicine 73(1):10-13.

Curtis KL, Weller AC, Hurd JM (1997). Information seeking behaviour of health science faculty: the impact of new information technologies. Bulletin Med Library Assoc 85(4):402-410.

Demirjian A (1991). A new teaching tool for dental and medical schools: multimedia CD-ROM on dental and skeletal development. Journal of Medical Systems. 15(1):37-46.

Demirjian A, David B (1995). Multimedia approach to dental education in the 21st century. New York State Dental J 61 (8):58-62.

Desch LW. Esquivel MT. Anderson SK (1991). Comparison of a computer tutorial with other methods for teaching well-newborn care. American Journal of Diseases of Children. 145(11):1255-1258.

Devitt P, Palmer A (1998). Computers in medical education1: evaluation of a problem orientated learning package. Aust NZ J Surg 68: 284-287.

Dixon W (1993). BMDP statistical software manual. Los Angeles, UCLA Press.

Doherty RL (chairman) 1988. Australian medical education and workforce into the 21st century. Committee of Inquiry into Medical Education and Medical Workforce. Canberra, Australian Government Publishing Services.

Duguid KP (1995). The team approach to the design of computer-assisted learning packages in medicine. Journal of Audiovisual Media in Medicine. 18(2):53-58.

Engel SS. Crandall J. Basch CE. Zybert P. Wylie-Rosett J (1997). Computer-assisted diabetes nutrition education increases knowledge and self-efficacy of medical students. Diabetes Educator. 23(5):545-549.

Eno K. Sundsten JW. Brinkley JF (1991). A multimedia Anatomy Browser incorporating a knowledge base and 3D images. Proceedings - the Annual Symposium on Computer Applications in Medical Care. :727-731.

Felciano RM. Dev P (1994). Multimedia clinical simulation based on patient records: authoring, user interface, pedagogy. Proc Annu Symp Comput App Med Care:59-63

Flexner A (1910). Medical education in the United Sates and Canada. A report to the Carnegie Foundation for the advancement of teaching.. Bulletin no.4, Boston, Updyke.

Friedman CP. de Bliek R. Gilmer JS. Twarog RG. File DD (1992). Influence of a computer database and problem exercises on students' knowledge of bacteriology. Academic Medicine. 67(5):332-338.

Friedman CP. Oxford GS. Juliano EL (1991). A collaborative institutional model for integrating computer applications in the medical curriculum. Proceedings - the Annual Symposium on Computer Applications in Medical Care. :752-756.

General Medical Council: Educational Committee (1980). Recommendations for basic medical education. London, General Medical Council.

General Medical Council: Educational Committee (1993). Tomorrows doctors. London, General Medical Council.

GPEP (1984). Report of the project panel on the general professional education of the physician and college preparation for medicine. Assoc of American Medical Colleges.

Glenn J (1996). A consumer orientated model for evaluating computer-assisted instructional materials for medical education. Academic Medicine 71(3):251-255.

Habbal OA. Harris PF (1995). Teaching of human anatomy: a role for computer animation. Journal of Audiovisual Media in Medicine. 18(2):69-73.

Hardman DT. Patel MI. Delbridge L (1997). Teaching normal physical examination in a large-group interactive using artists' models. Australian & New Zealand Journal of Surgery. 67(7):468-471.

Hesketh B, Gosper M, Andrews J, Sabaz M (1996). Computer-mediated communication in University teaching. Canberra, Australian Govt Publishing Services.

Hobsley M. McCloy R. Jameson DG. Buckton S. O'Hanlon P (1997). Lessons learned during the INSURRECT project (INteractive SURgical Teaching at REmote CeNtres). Journal of Telemedicine and Telecare. 3 Suppl 1:38-40.

Hoffman H, Vu D (1997). Virtual reality: teaching tool of the twenty-first century? Academic Medicine 72(12):1076-1081

Hong D. Regehr G. Reznick RK (1996). The efficacy of a computer-assisted preoperative tutorial for clinical clerks. Canadian Journal of Surgery. 39(3):221-224.

Hooper J. O'ConnorJ, Cheesmar R (1996). Learning clinical biochemistry using multimedia interactive clinical cases. Clinica Chimica Acta 248(1):119-123.

Jaffe CC, Lynch PJ (1993). Computer aided instruction for radiologic education. Radiographics 13(4):931-937.

Jameson DG. O'Hanlon P. Buckton S. Hobsley M (1995). Broadband telemedicine: teaching on the information superhighway. Journal of Telemedicine and Telecare. 1(2):111-116.

Jelovsek FR, Catanzarite VA, Price RD, Stull RE (1989). M.D.Computing 6(5):267-273.

Karmel P (chairman) 1973. Expansion of medical education. Report of the committee on medical schools to the Australian Universities Commission. Canberra, Australian Government Publishing Services.

Kaufman D. Lee S (1993). Formative evaluation of a multimedia CAL program in an ophthalmology clerkship. Medical Teacher. 15(4):327-340.

Keerl R, Schauss F, Weber R (1997). The role of the multimedia teacing in the evolution of learning endonasal surgery of the sinuses. Rev Laryngol Otol Rhinol 118(2):129-132

Kettenbach J. Gahleitner A. Schick S. Petta P. Veitl M. Imhof H (1995). MRI-pool: the "Vienna blend". An interactive computer-assisted teaching system for MRI. Radiologe. 35(9):592-597.

Kiley R (1996). Medical information on the Internet: a guide for health professionals. Edinburgh, Churchill Livingstone.

Klemenz B, Mc Sherry D, Grundkle V (1997). Clinical problem solving by computer. J Royal College Physicians London 31(1):32-36.

Koch B. Guice R (1989). Teaching electrocardiography: computer assisted learning vs lecture method. Australian Journal of Advanced Nursing. 6(4):33-39.

Kovacs G (1997). Procedural skills in medicine: linking theory to practice. J Emergency Med 15(3):387-391.

Kumar K. Hodgins M (1990). Use of interactive videodisc for teaching of pathology laboratory cases. Journal of Pathology. 160(2):145-149.

Lawrence S (1993). Medical Education. Chapter 48. In WF Bynum and R Porter (eds): companion encyclopedia of the history of medicine. London, Routledge.

Lee W. Ault H. Kirk JS. Comstock CH (1995). Interactive multimedia for prenatal ultrasound training. Obstetrics & Gynecology. 85(1):135-140.

Letterie GS. Morgenstern LL. Johnson L (1994). The role of an electronic mail system in the educational strategies of a residency in obstetrics and gynecology. Obstetrics & Gynecology. 84(1):137-139.

Levine EB (1971). Hippocrates. New York, Twayne Publishers Inc.

Lonwe B. Heijl A (1993). Computer-assisted instruction in emergency ophthalmological care. Acta Ophthalmologica. 71(3):289-295.

Ludwig K, Bick U, Peters PE (1996). Product of the month: the Schering Atlas. Sectional anatomy ofCT and MRI images. Radiologe 36(2):172-173.

Mangione S. Nieman LZ. Greenspon LW. Margulies H (1991). A comparison of computer-assisted instruction and small-group teaching of cardiac auscultation to medical students. Medical Education. 25(5):389-395.

Mankovich NJ. Verma RC. Yue A. Veyne D. Ratib O. Bennett LR (1991). NMINT--introductory course-ware for nuclear medicine: database design. Proceedings - the Annual Symposium on Computer Applications in Med Care: 757-761.

Mars M. McLean M (1996). Students' perceptions of a multimedia computer-aided instruction resource in histology.South African Medical Journal. 86(9):1098-1102.

Martin DS. Brindley B. Awwad EE (1993). A versatile, inexpensive, intuitive and simple system for computer-assisted instruction in radiology. Computerized Medical Imaging & Graphics. 17(2):101-106.

McCracken TO. Spurgeon TL (1991). The Vesalius Project: interactive computers in anatomical instruction. Journal of Biocommunication. 18(2):40-44.

McEnery KW. Roth SM. Kelley LK. Hirsch KR. Menton DN. Kelly EA (1995). A method for interactive medical instruction utilizing the World Wide Web. Proceedings - the Annual Symposium on Computer Applications in Medical Care. :502-507.

McLaren PM. Ball CJ. Summerfield AB. Lipsedge M. Watson JP (1992). Preliminary evaluation of a low cost videoconferencing system for teaching in clinical psychiatry. Medical Teacher. 14(1):43-47.

Merril GL. Barker VL (1996). Virtual reality debuts in the teaching laboratory in nursing. Journal of Intravenous Nursing. 19(4):182-187.

Minorati D, Lazzerini F, Blanc M, Gattoni F, Nessi R, Uslenghi CM (1995). Photo compact disc: proposal for the electronic storage of images. Radiologia Medica 89(5):675-678.

Montanari N, Bertolani M, Romagnoli R, Spina V, Torricelli P (1996). Interactive atlas with magnetic resonance on CD_ROM for Macintosh. Radiologia Medica 92(5):610-613.

Newble DI (1992). Assessing clinical competence at the undergraduate level. Medical Education. 26(6):504-511.

Newble DI, Dawson B, Dauphinee D, Page G, Macdonald M, Mulholland H, et al (1994). Guidelines for assessing clinical competence. Teaching and Learning in Medicine 6(3):213-220.

Newble DI, Paget NS (1996). The maintenance of professional standards programme of the Royal Australian College of Physicians. J Royal College Physicians of London 30(3):252-256.

Newman C (1957). The evolution of medical education in the nineteenth century. London, Oxford University Press, 1957.

Nunnaly RH (1994). Computer disc revolution. J Arkansas Med Societ 90(12):593-594.

Occhiato R. Broglia L. Laghi A. Sarrantonio A. Drudi FM. Campanella V. Pavone P. Passariello R (1996). An integrated approach to senology education: combination of a hypermedia program with a multimedia archive. European Radiology. 6(4):532-535.

Ostbye T. White M. Hoffer G. Bojan F (1995). The electronic medical-student exchange: a low-cost alternative to overseas electives. CMAJ. 153(9):1327-1328.

Papa FJ. Meyer S (1989). A computer-assisted learning tool designed to improve clinical problem-solving skills. Annals of Emergency Medicine. 18(3):269-273.

Piemme TE (1988). Computer-assisted learning and evaluation in medicine. JAMA. 260(3):367-372.

Parker R, Rossman P (1992). The emerging worldwide electronic university. Westport, Greenwood Press.

Porter R (1996). Hospitals and surgery. Chapter 6. In R Porter (ed): Cambridge illustrated history of Medicine. Cambridge, Cambridge University Press, 1996.

Prolla JC. da Silva VD. Muller RL. Muller RL (1997). Image quest: A model self-assessment and self-teaching program for cytopathology. Acta Cytologica. 41(5):1497-1499.

Rees L. Wass J (1993). Undergraduate medical education. BMJ. 306:258-261.

Richardson D (1997). Student perceptions and learning outcomes of computer-assisted versus traditional instruction in physiology. American Journal of Physiology. 273(6 Pt 3):55-58.

Ringenberg QS. Johnson ED. Doll DC. Anderson SP. Yarbro JW (1989). Computer-assisted instruction in cancer for third-year medical students using the Physician Data Query (PDQ) system. Journal of Cancer Education. 4(1):11-15.

Roberts BV. Cleary EG. Roberts JV (1997). Graded check lists to assist undergraduate students in self-directed learning and assessment in general and systematic anatomical pathology. Pathology. 29(4):370-373.

Rosner L (1997). The growth of medical education and the medical profession. Chapter 9. In I Loudon (ed): An illustrated history of Western Medicine. Oxford, Oxford University Press.

Rosser J (1996). CD-ROM multimedia. The step before virtual reality. Surgical Endoscopy 10(10):1033-1035.

Samsel RW. Schmidt GA. Hall JB. Wood LD. Shroff SG. Schumacker PT (1994). Cardiovascular physiology teaching: computer simulations vs. Animal demonstrations. American Journal of Physiology. 266(6 Pt 3):36-46.

Sajid AW, McGuire CH, Aziz LR, Gunzburger LK (1994). International handbook of medical education. Westport (Connecticut), Greenwood Press.

Savitt DL. Steele DW (1997). Implementation of a hypertext-based curriculum for emergency medicine on the World Wide Web. Academic Emergency Medicine. 4(12):1159-1162.

Schor NF. Troen P. Adler S. Williams JG. Kanter SL. Mahling DE. Sorrows B. Skogseid I. Bernier GM Jr (1995). Integrated case studies and medical decision making: a novel, computer-assisted bridge from the basic sciences to the clinics. Academic Medicine. 70(9):814-817.

Schubert E. Gross W. Becich MJ (1994). Computer-assisted instruction in pathology residency training: design and implementation of integrated productivity and education work-stations. Seminars in Diagnostic Pathology. 11(4):282-293.

Schwartz S. Griffin T (1993). Comparing different types of performance feedback and computer-based instruction in teaching medical students how to diagnose acute abdominal pain. Academic Medicine. 68(11):862-864.

Sestini P. Renzoni E. Rossi M. Beltrami V. Vagliasindi M (1995). Multimedia presentation of lung sounds as a learning aid for medical students. European Respiratory Journal. 8(5):783-788.

South M, Nolan T (1993). Computer assisted instruction in Australian medical schools. Medical J Australia 159:175-176.

Spurgeon D (1996). Canadian firm's sofware helps physicians diagnose fetal abnormalities. CMAJ 154(11):1733-1734.

Taylor JC, White VJ (1991). Department of Employment , Education and Training Report: The evaluation of the cost-effectiveness of multi-media mixed-mode teaching and learning. Canberra, Australian Govt Publishing Services.

Tervo RC, Dimitrievich E, Trujillo AL, Whittle K, Redinius P, Wellman L (1997). The objective structured clinical examination (OSCE) in the clinical clerkship: an overview. South Dakota J Medicine 50(5):153-156.

Todd AR (chairman) 1968. Report of the Royal Commission on Medical Education. London, HMSO.

Trelease RB (1996). Toward virtual anatomy: a stereoscopic 3-D interactive multimedia computer program for cranial osteology. Clinical Anatomy. 9(4):269-272.

Vicente KJ, Wang JH (1998). An ecological theory of expertise effects in memory recall. Psychological Review. 105(1):33-57

Vickers JD (1990). Catching information technology by the tail for problem-based learning. Journal of Dental Education. 54(9):557-559.

Wang MJ. Contino PB. Ramirez ES (1997). Implementing cognitive learning strategies in computer-based educational technology: a proposed system. Proceedings/AMIA Annual Fall Symposium. 703-707.

Wee JG (1990). New waves, new problems-use of CD-ROM Medline in the medical library of the National University of Singapore. Annals Academy Medicine, Singapore 19(5):571-579.

Woolridge N (1995). The C-ASE Project: computer-assisted simulated examination. Journal of Audiovisual Media in Medicine. 18(4):149-155.

World Federation for Medical Education (1988). The Edinburgh declaration of the world conference on medical education: report. Edinburgh.

World Health Organisation. Division of Development of Human resources for Health 1978. Declaration of Alma Ata on Primary Health Care. Report of the Conference on Primary Health Care as Alma Ata, USSR, 6-12 September 1978. Geneva, WHO.

Wright DN (1995). Interactive multimedia dental education: the next five years and beyond. Medinfo. 8 Pt 2:1305-1307.

Yamamoto LG (1994). Storing radiographics on a PC using a hand scanner: a simple tool to improve the teaching quality of radiaographs in medical education. American J Emergency Med 12(4):459-462.

Young HL (1996). Satellite-delivered medical education and training for central Europe: a TEMPUS project. Trans-European Mobility Programme for University Students. Journal of Telemedicine and Telecare. 2(1):14-19.

Zenz H. Maresch H. Faulborn J (1994). Interactive, multimedia learning system for the study of primary open angle glaucoma--system description from the viewpoint of the computer scientist. Biomedizinische Technik. 39(1-2):27-30.

APPENDIX A

MEDLINE SEARCH LIST OF PUBLICATIONS RELATING TO MM DEVELOPED FOR MEDICAL UNDERGRADUATE TEACHING.

Anatomy:	Eno et al 1991, Mc Cracken and Spurgeon 1991, Habbal and Harris 1995, Kettenback et al 1995, Lugwig et al 1996, MonatanAri et al 1996, Trelease 1996.
Cardiac Auscultation:	Criley et al 1996, MangIone et al 1991.
Clinical Biochemistry:	Hooper et al 1996.
Clinical Skills:	Felciano and Dev 1994,
(inter-active, simulated patient encounters)	Hayes and Lehmann 1996, Cobbs et al 1994
Diabetic Nutrition:	Engel et al 1997.
Otolaryngology:	Keerl et al 1997.
Electrocardiography:	Koch and Guice 1989.
Emergency Anaesthesia:	Byrne et al 1994.
Emergency Medicine:	Papa and Meyer 1989, Schwartz and Griffin 1993, Savitt and Steele 1997.
General Medicine:	Schor et al 1995
General Surgery:	Jameson et al 1995, Devitt and Palmer 1998.
General Surgical Anatomy:	Hong et al 1996, Merril and Barker 1996.
Laparoscopy:	Rosser 1996.
Neonatology:	Desch et al 1991.
Nuclear Medicine:	Mankovich et al 1991.
Occupational Mediciane:	Bresnitz et al 1992.
Oncology:	Ringenberg et al 1989, Occhiato et al 1996.
Ophthalmology:	Kaufman and Lee 1993, Lonwe and Heijl 1993, Zenz et al 1994.
Pathology:	Kumar and Hodgins 1990, Schubert et al 1994, Andrew and Benbow 1997, Prolla et al 1997, Roberts et al 1997.
Physical Examination:	Sestini et al 1995, Woolridge 1995, Hardman et al 1997.
Physiology:	Samsel et al 1994, Richardson 1997.

Pressure Ulcer Management: Bolwell 1993.

Radiology: Demirjian 1991, Jaffe and Lynch 1993, Martin et al 1993, Calhoun and Fishman 1994, Chew and Stiles 1994, Yamamoto 1994, Chew and Smirniotopoulos 1995, Mc Enery et al 1995, Achenbach et al 1997, Klemenz et al 1997.

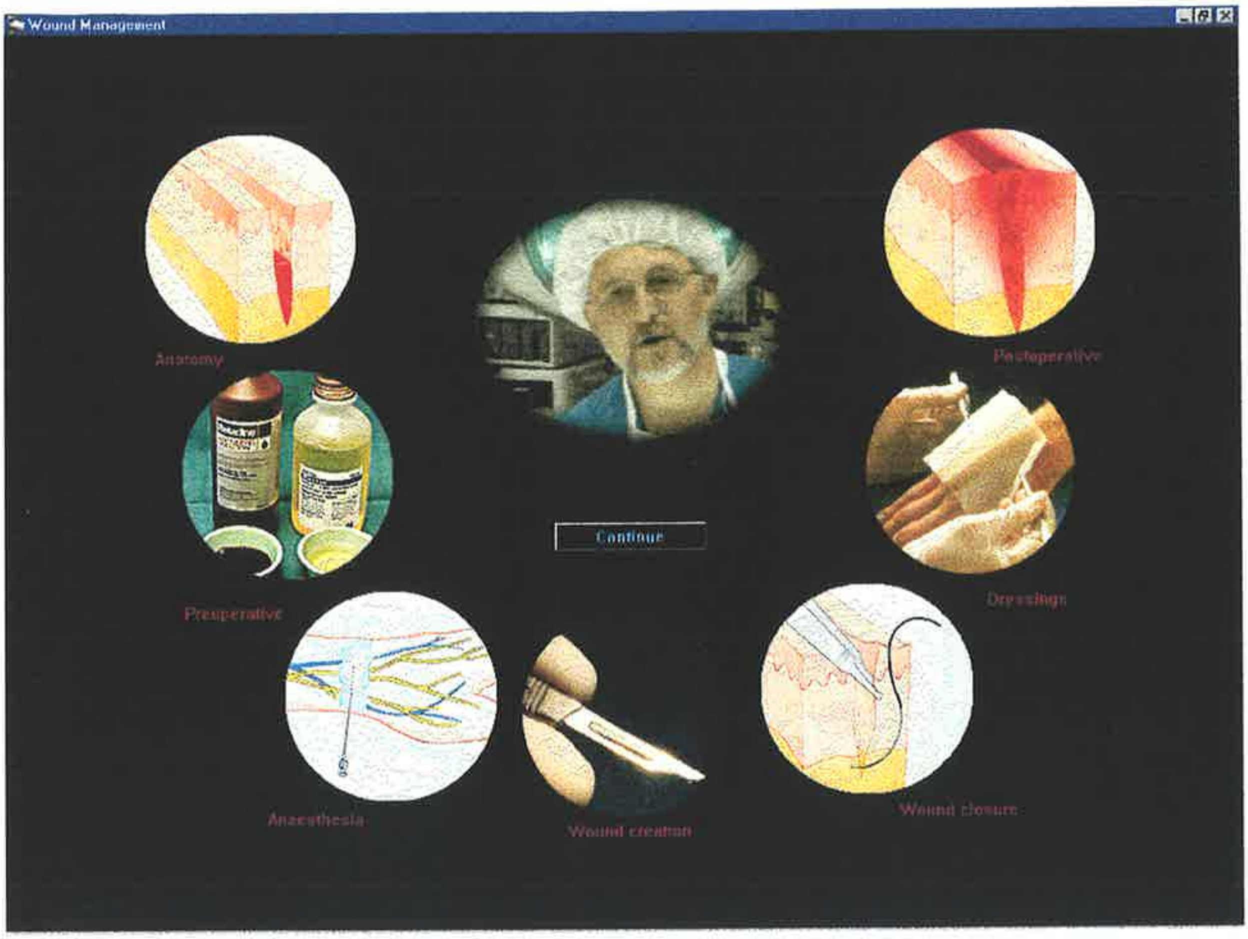
Rheumatology: Bridges et al 1993.

Ultrasonography: Lee et al 1995, Spurgen et al 1996.

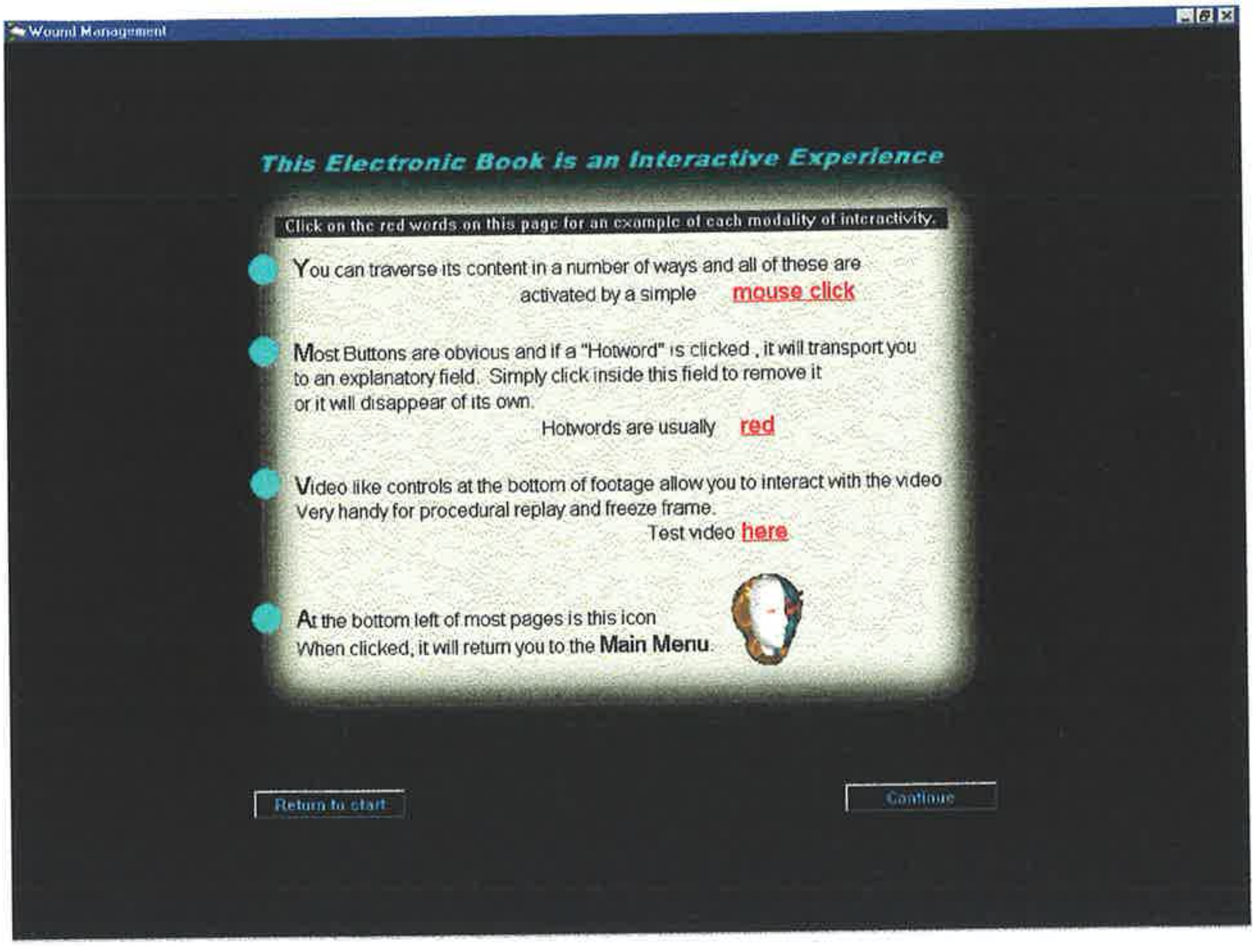
APPENDIX B

TEACHING MATERIAL FROM PSWM SEEN BY MEDICAL STUDENT COMPUTER GROUP

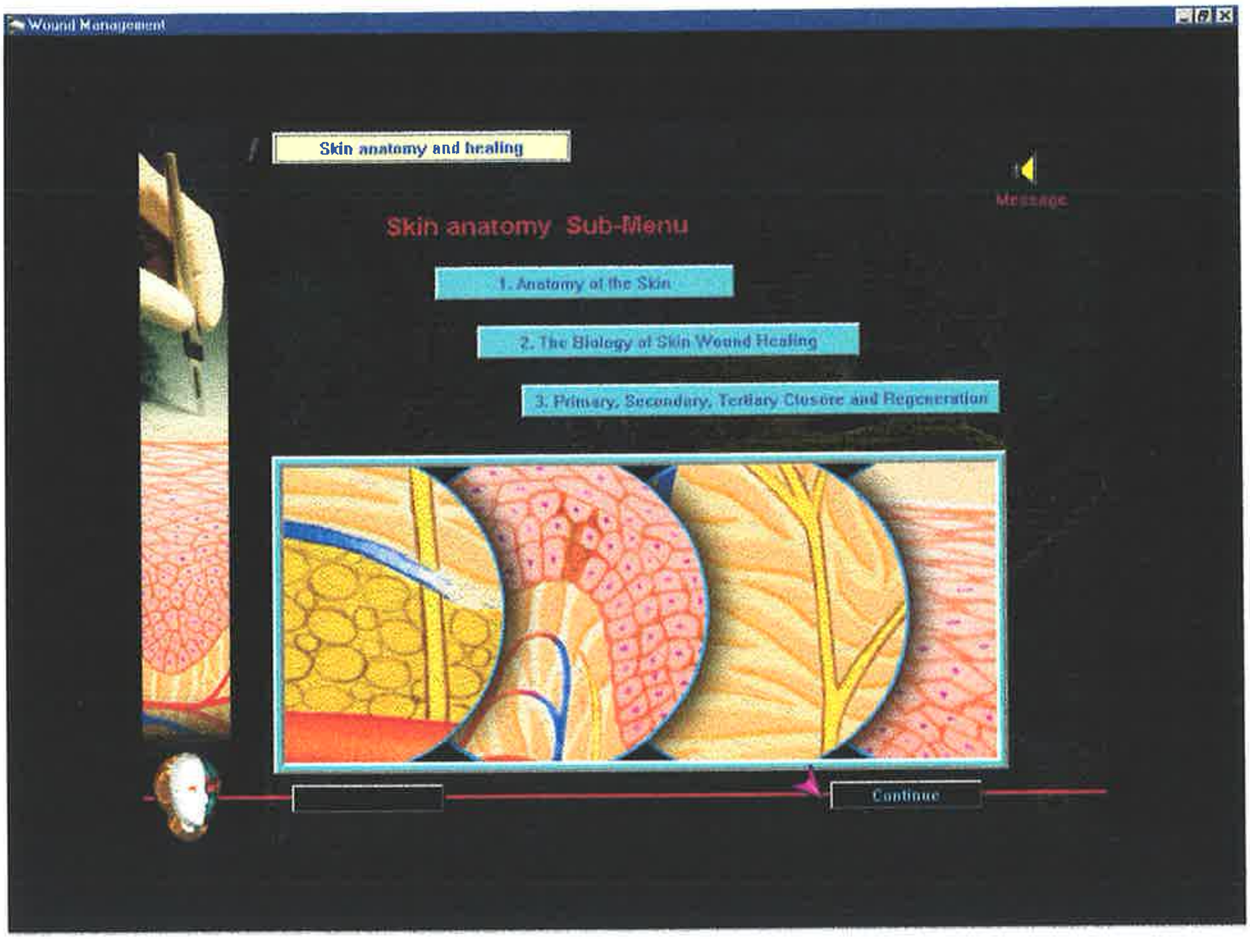
Main Menu Page



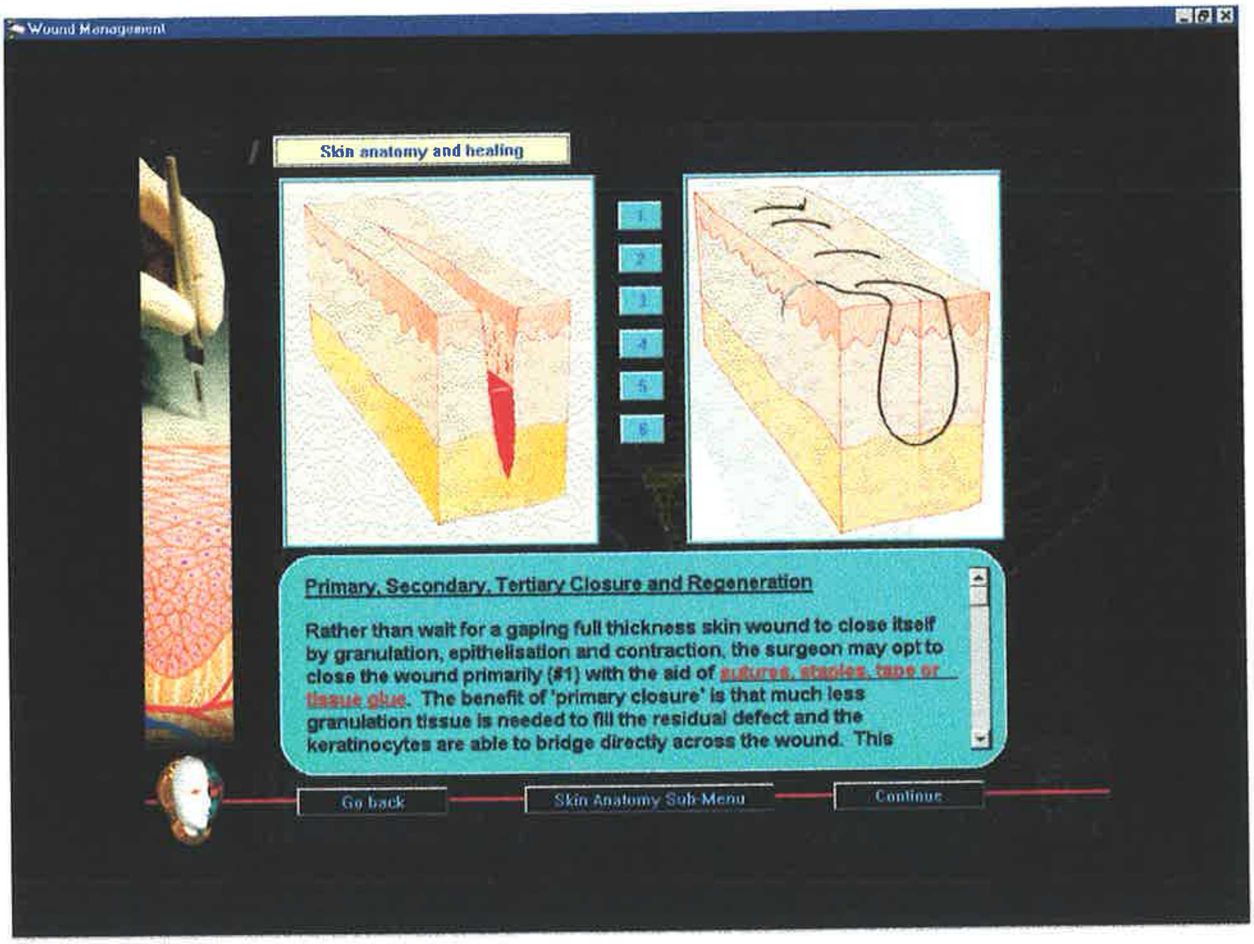
Welcoming Page



Instruction Page



Sub Menu page for Module 1 "Skin Anatomy and Wound Healing"



Section in Module 1 entitled "Primary, Secondary, Tertiary Closure and Regeneration"

Full text and References Pages for the Section Entitled: Primary, Secondary, Tertiary Closure and Regeneration

Primary, Secondary, Tertiary Closure and Regeneration

Rather than wait for a gaping full thickness skin wound to close itself by granulation, epithelisation and contraction, the surgeon may opt to close the wound primarily with the aid of sutures, staples, tape, or tissue glue. The benefit of 'primary closure' is that much less granulation tissue is needed to fill the residual defect and the keratinocytes are able to bridge directly across the wound. This direct process of re-epithelisation is called 'healing by primary intention'. Healing by this method is much faster and the resultant scar is considerably finer.[1,2]

Wounds that cannot be closed directly due to their extent of full thickness skin loss, may be closed by skin grafts or flaps. If this is not desirable, then the wound may be left to heal itself, so long as it has a good blood supply and is not frankly infected. In this type of wound healing, epithelisation eventually occurs over an advancing base of good quality granulation tissue. It is therefore called 'healing by secondary intention' (#2) and the process of allowing such wounds to close themselves is referred to as 'secondary closure'.[1-2] This is a popular method for healing lower limb ulcers and some finger tip pulp losses of $<1cm^2$. Screen #3 shows a medial malleolar ulcer which healed within 3 months using compressive dressings. Screen #4 shows crush, amputation injuries to finger-tips treated with colloid dressings and healing by 3 weeks.

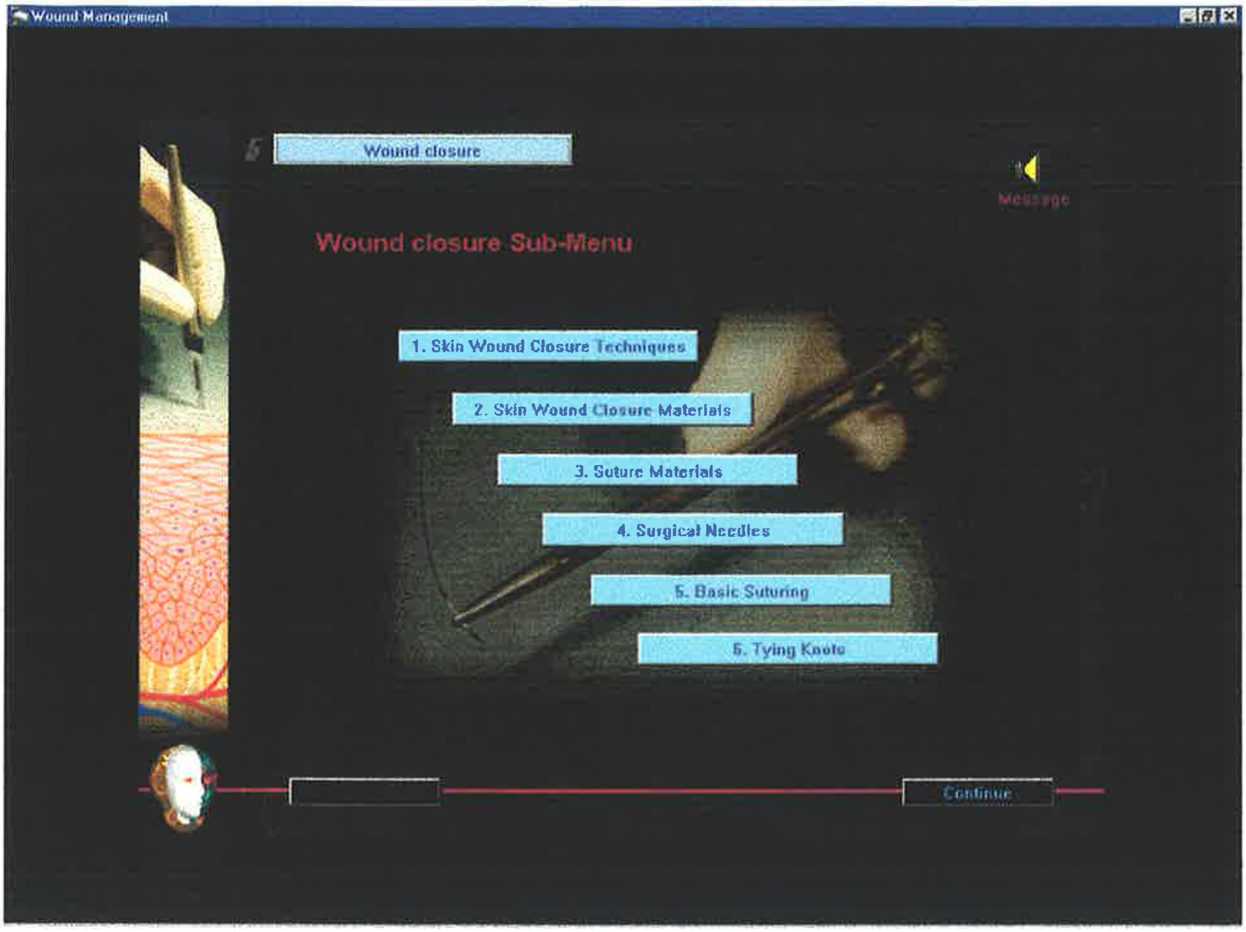
Occasionally, wounds are too oedematous to close primarily. They can be dressed and left for the oedema to subside over the following 48 to 72 hours, then closed. This is called 'delayed primary closure'. As granulation tissue is not established by this time, such wound closures are still said to heal by primary intention.[1] If surgical closure is further delayed macroscopic granulation tissue begins to fill in the wound. Subsequent surgical closure is termed 'tertiary closure' and these wounds are said to heal by 'tertiary intention', ie. a combination of primary and secondary healing. Where possible, it is best to close wounds before the formation of granulation tissue as this increases the volume of permanent scar tissue.

This practice is beneficial in managing deep contaminated wounds with devitalised tissues, such as war wounds. However isolated skin wounds are best managed by thorough early debridement and primary closure where possible.[3]

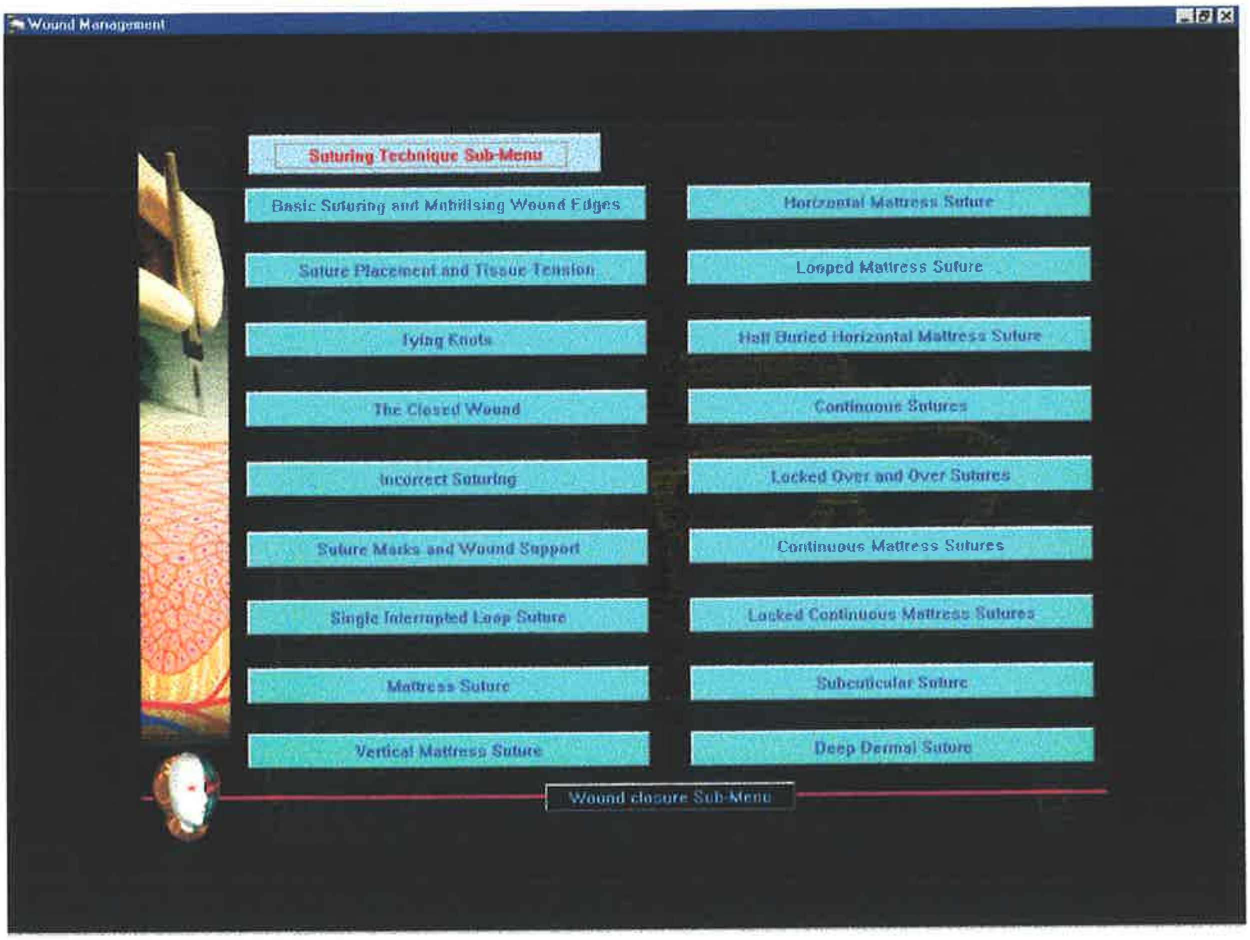
Superficial skin wounds with partial epidermal loss, such as with abrasions and shallow burns, will heal solely by epithelial regeneration (#5,6). Even full thickness epidermal loss with superficial dermal loss, will heal by epithelial regeneration from the wound's edge and from the epithelial cells lining the pilo-sebaceous units.[1,2]

<u>References</u>

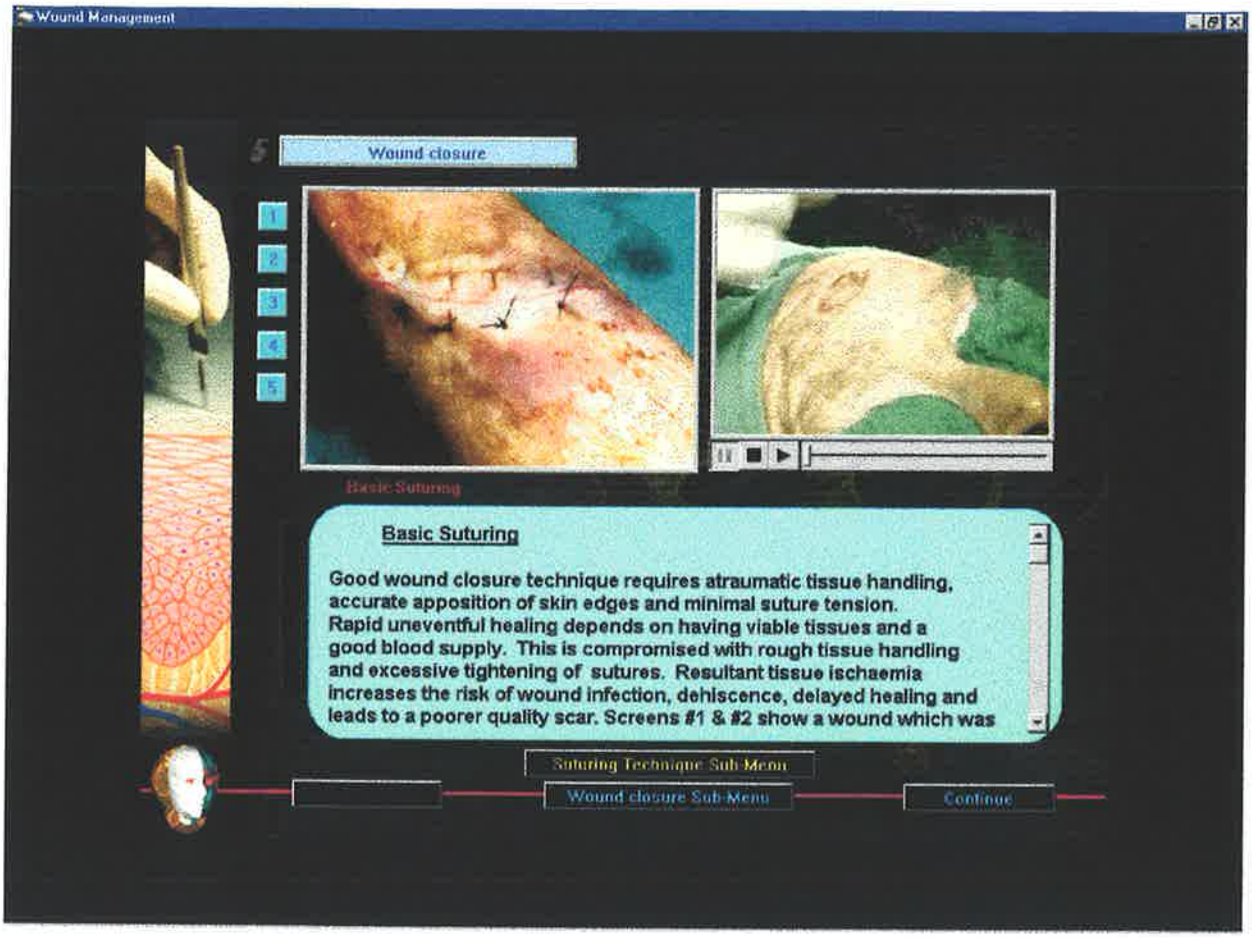
1. Asmussen PD, Sollner B: Principles of healing. Stuttgart, Beiersdorf Medical Bibliothek, 1993, pp52 - 66.
2. Amenta P, Martinez-Hernandez A, Trelstad R L: Repair and regeneration. Chapter 19. In I Damjanov and J Linder (Eds): Anderson's Pathology (10th ed). St Louis, Mosby, 1996, pp416 - 447.
3. Weinzweig N, Weinzweig J: Basic principles and techniques in Plastic Surgery. Chapter 2. In Cohen M (Ed): Mastery of Plastic and Reconstructive Surgery (1st ed). Boston, Little, Brown and Co., 1994, pp32.



Sub Menu for Module 5 "Wound Closure"



Sub, Sub menu page for Suturing Section of Module 5.



First page of Suturing Section entitled "Basic Suturing"

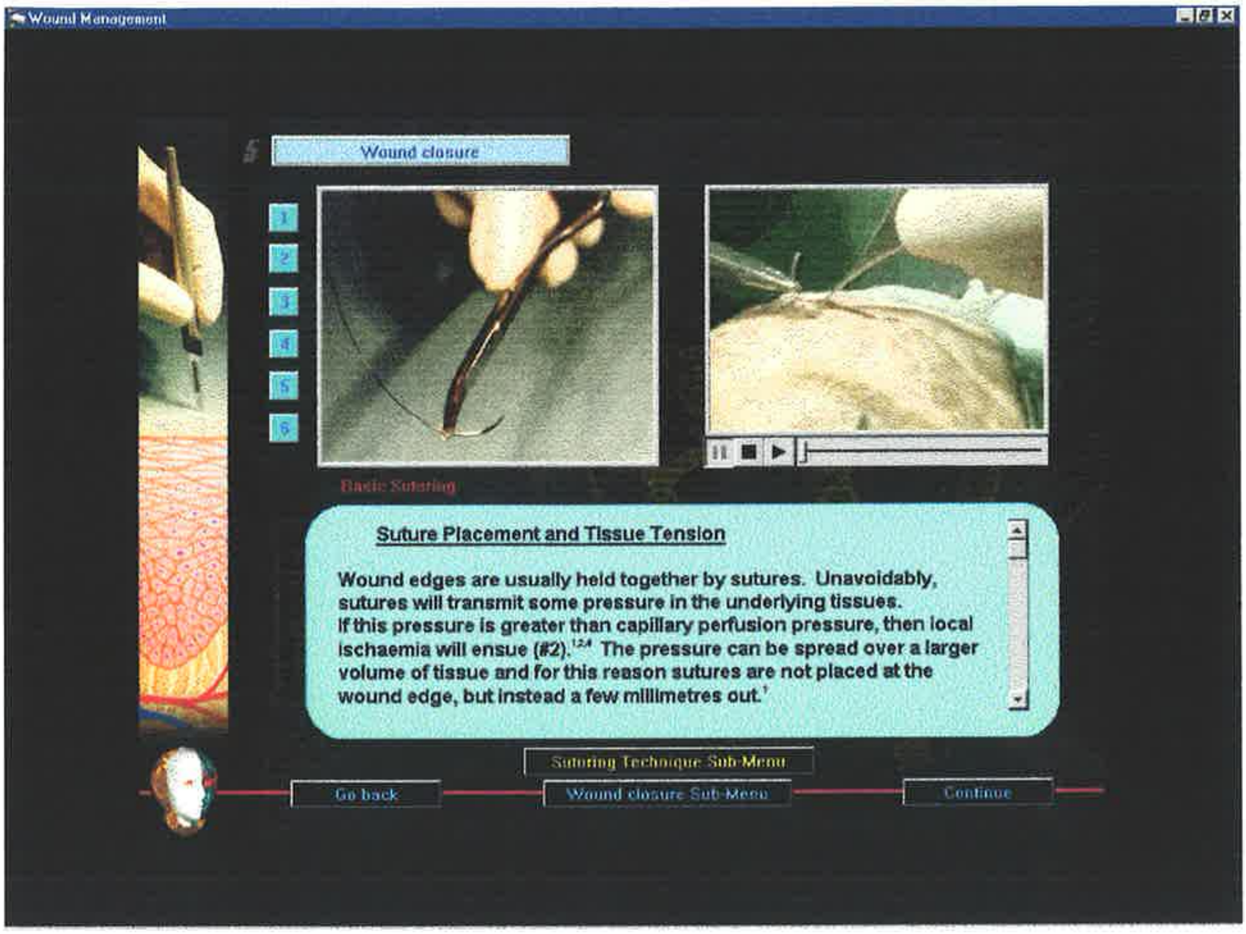
Full Text for First Page of Suturing Section

Basic Suturing

Good wound closure technique requires atraumatic tissue handling, accurate apposition of skin edges and minimal suture tension. Rapid uneventful healing depends on having viable tissues and a good blood supply. This is compromised with rough tissue handing and excessive tightening of sutures. Resultant tissue ischaemia increases the risk of wound infection, dehiscence, delayed healing and leads to a poorer quality scar. Screen #4&5 show a wound which was subjected to excessive closure tension. The wound edges necrosed and dehisced. Where direct closure is possible, complications can be avoided by gentle wound edge mobilisation and careful suture placement. If wound closure tension is still high, then skin may be imported into the wound as skin flaps or grafts.[1-4]

Mobilising wound edges

Skin edges are mobilised by using toothed forceps or skin hooks on the resilient dermis (#3-5). If necessary the skin can be further mobilised with judicious undermining.[2,3] However this should be kept to a minimum as it reduces blood supply to the wound edges and creates a potential dead space.[1-3]



Second page of Suturing Section entitled "Basic Suturing"

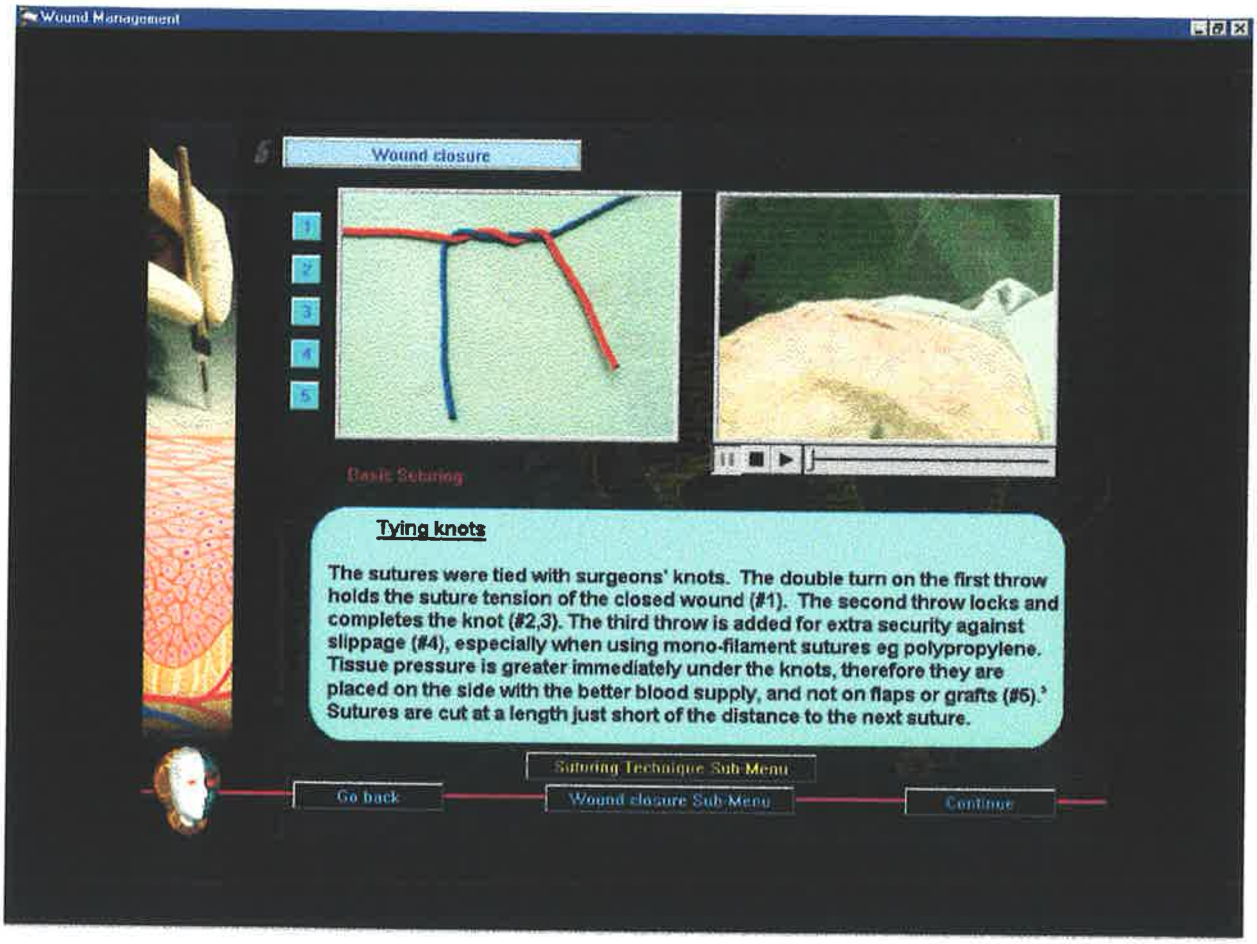
Full text for the Second Page of the Suturing Section

Suture Placement and Tissue Tension

Wound edges are usually held together by sutures. Unavoidably, sutures will transmit some pressure in the underlying tissues. If this pressure is greater than capillary perfusion pressure, then local ischaemia will ensue.[1,2,4] The pressure can be spread over a larger volume of tissue and for this reason sutures are not placed at the wound edge, but instead a few millimetres out.[1]

Suture Eversion of Wound Edges

Furthermore, by everting the skin edge and passing the needle vertically downwards, at an angle of 90^0 or more, one takes a larger bite of the dermis.[2,3] This greater amount of dermal tissue in the suture loop, is able to hold sutures better, shifts the tissue tension away from the epidermis and everts the skin edge (video and #3-6), all of which help to produce a better scar (#2-5).[1-4]

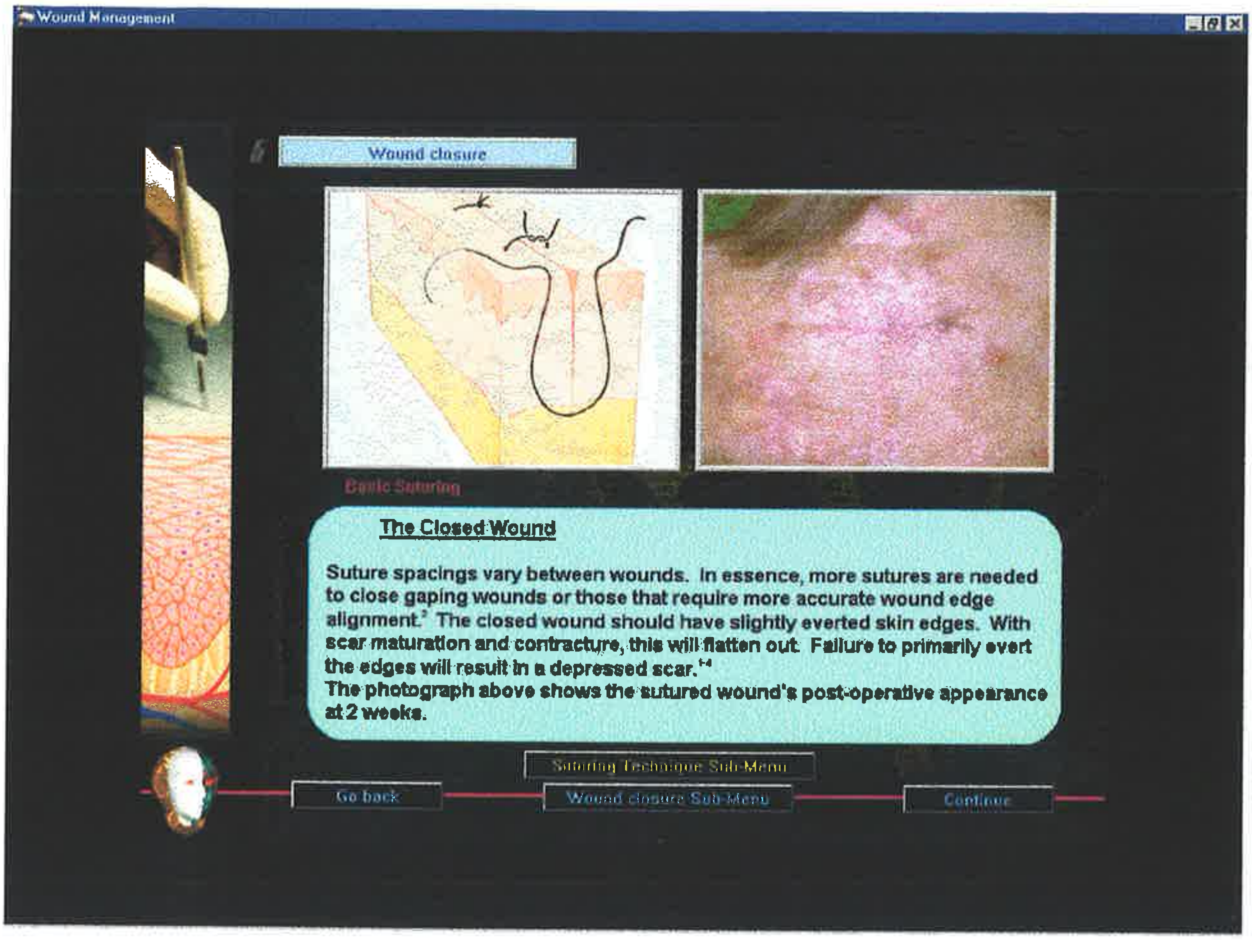


Third page of Suturing Section entitled "Tying Knots"

Full text for the Third Page of Suturing Section

Tying Knots

These sutures were tied with surgeons' knots. The double turn on the first throw holds the suture tension of the closed wound (#1). The second throw locks and completes the knot(#2,3). The third throw is added for extra security against slippage (#4), especially when using mono-filament sutures eg polypropylene. Tissue pressure is greater immediately under the knots, therefore they are placed on the side with the better blood supply, and not on flaps or grafts (#5).[3] Sutures are cut at a length just short of the distance to the next suture.



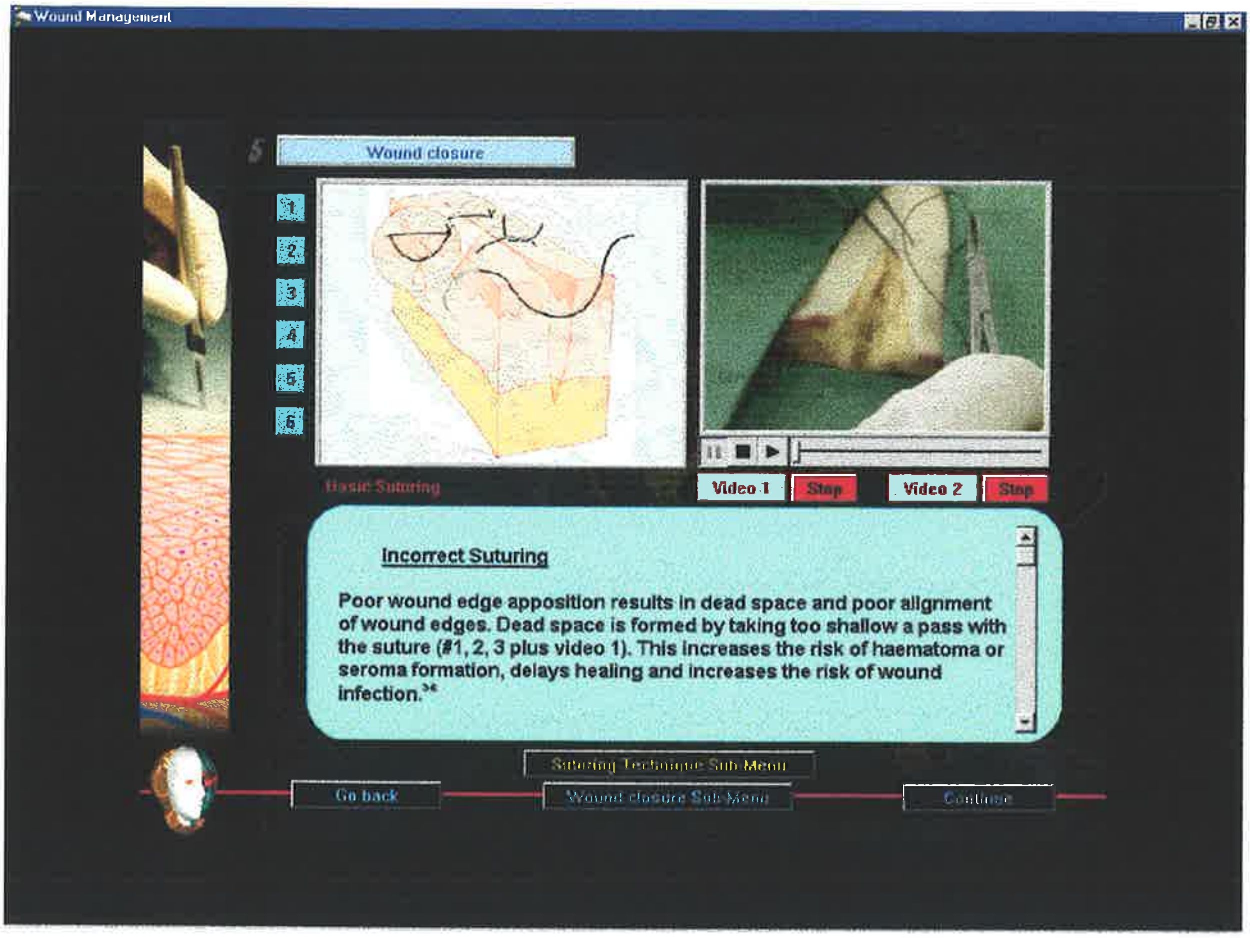
Fourth page of Suturing Section entitled "The Closed Wound"

Full text for the Fourth Page of Suturing Section

The Closed Wound

Suture spacings vary between wounds. In essence, more sutures are needed to close gaping wounds or those that require more accurate wound edge alignment.[2] The closed wound should have slightly everted skin edges. With scar maturation and contracture, this will flatten out. Failure to evert the edges will result in a depressed scar.[1-4]

The photograph above shows the wound with a good cosmetic appearance at 2 weeks.



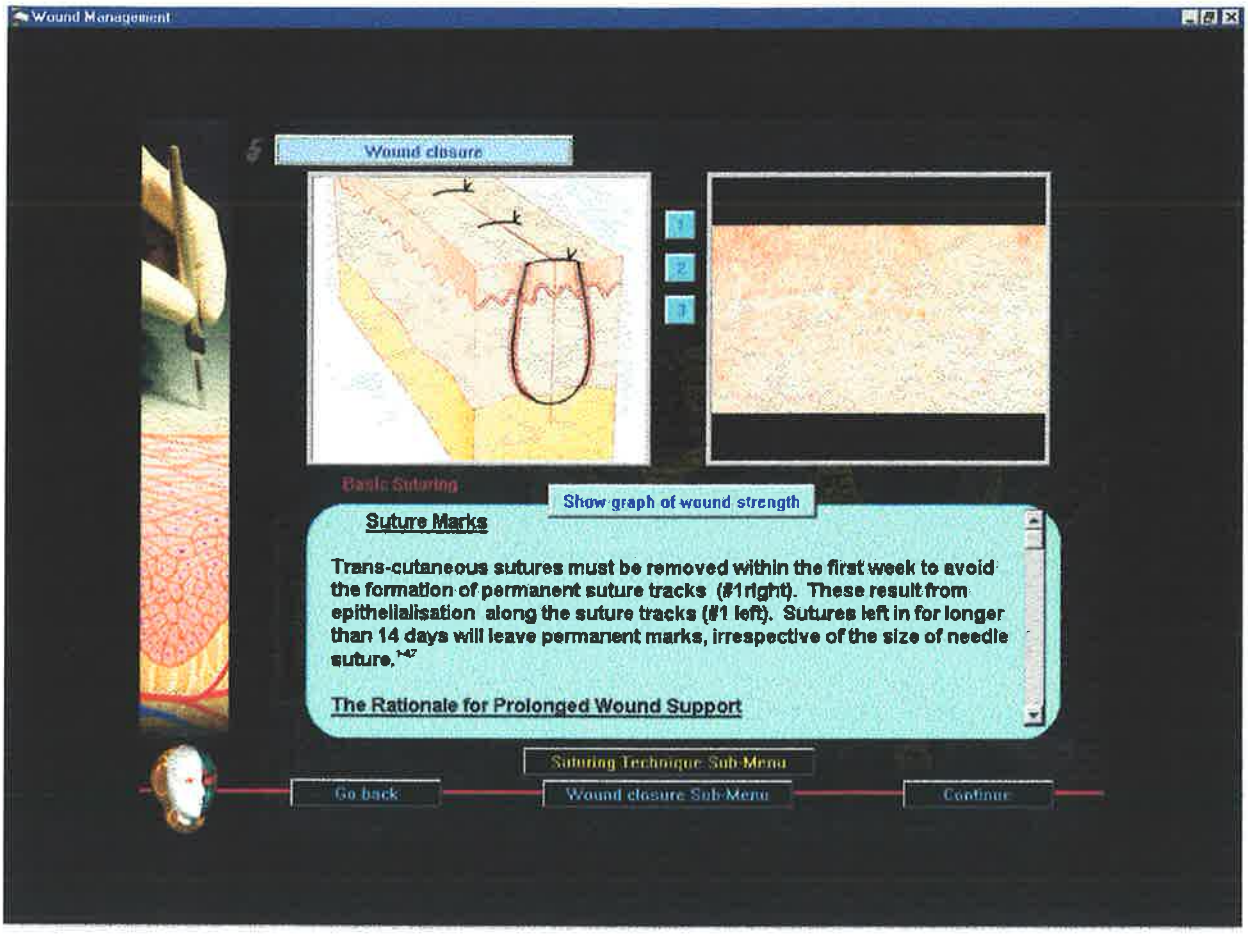
Fifth page of Suturing Section entitled "Incorrect Suturing"

Full Text for the Fifth Page of Suturing Section

Incorrect Suturing

Poor wound edge apposition results in dead space and poor alignment of edges. Dead space is formed by taking too shallow a pass with the suture (#1-3 plus video 1). This increases the risk of haematoma or seroma formation, delays healing and increases the risk of wound infection.[3-6]

Mismatched volumes of tissue in the suture loop leads to mismatching of the vertical height and gaping of the wound edges (#4-6, plus video 2). This also delays healing and produces wider, thicker scar.[3]



Sixth page of Suturing Section entitled "Suture Mark's" and "The Rationale for Prolonged Wound Support"

Full Text for the Sixth Page of Suturing Section

Suture Tracks

Trans-cutaneous sutures must be removed within the first week to avoid the formation of permanent suture tracks. These result from epithelialisation along the suture tracks. Sutures left in for longer than 14 days will leave permanent marks, irrespective of the size of needle or suture.[1-4,7]

The Rationale for Prolonged Wound Support

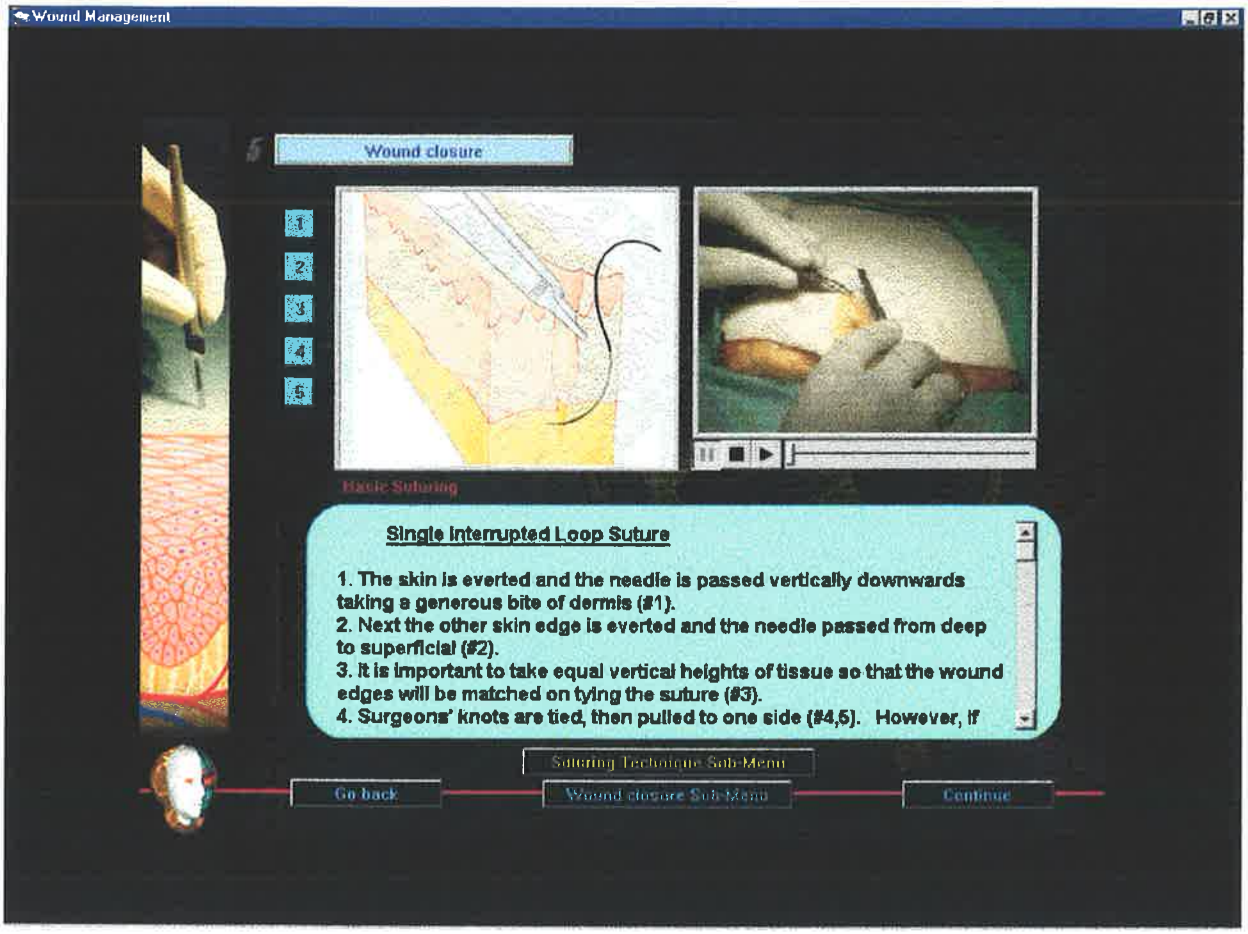
However the wound's tensile strength in the first week is less than 5% of normal and will easily dehisce or at least stretch, if the trans-cutaneous sutures are removed.[4,8-10] Screen #2 shows two forehead wounds following percutaneous suture removal at 1 week. The one on the right has partly dehisced as it was closed with only a single layer of percutaneous sutures. The wound on the left was closed with an additional layer of dermal sutures and remains intact. For this reason extra support can be provided to the healing wound by either:

a) deep dermal sutures or the

b) long term application of adhesive skin tape following the removal of the trans-cutaneous sutures.[1,2,4,11,13]

The duration of required wound support is controversial, however a good guide is to maintain support until the scar attains a normal skin colour after its hyperaemic phase. This may take several months.[2]

We will now look at the types of suture techniques for skin wound closure, starting with the most commonly used stitch, the single interrupted.[1-4]



Seventh page of Suturing Section entitled "Single Interrupted Loop Sutures"

Full Text for the Seventh Page of Suturing Section

Single Interrupted Loop Suture

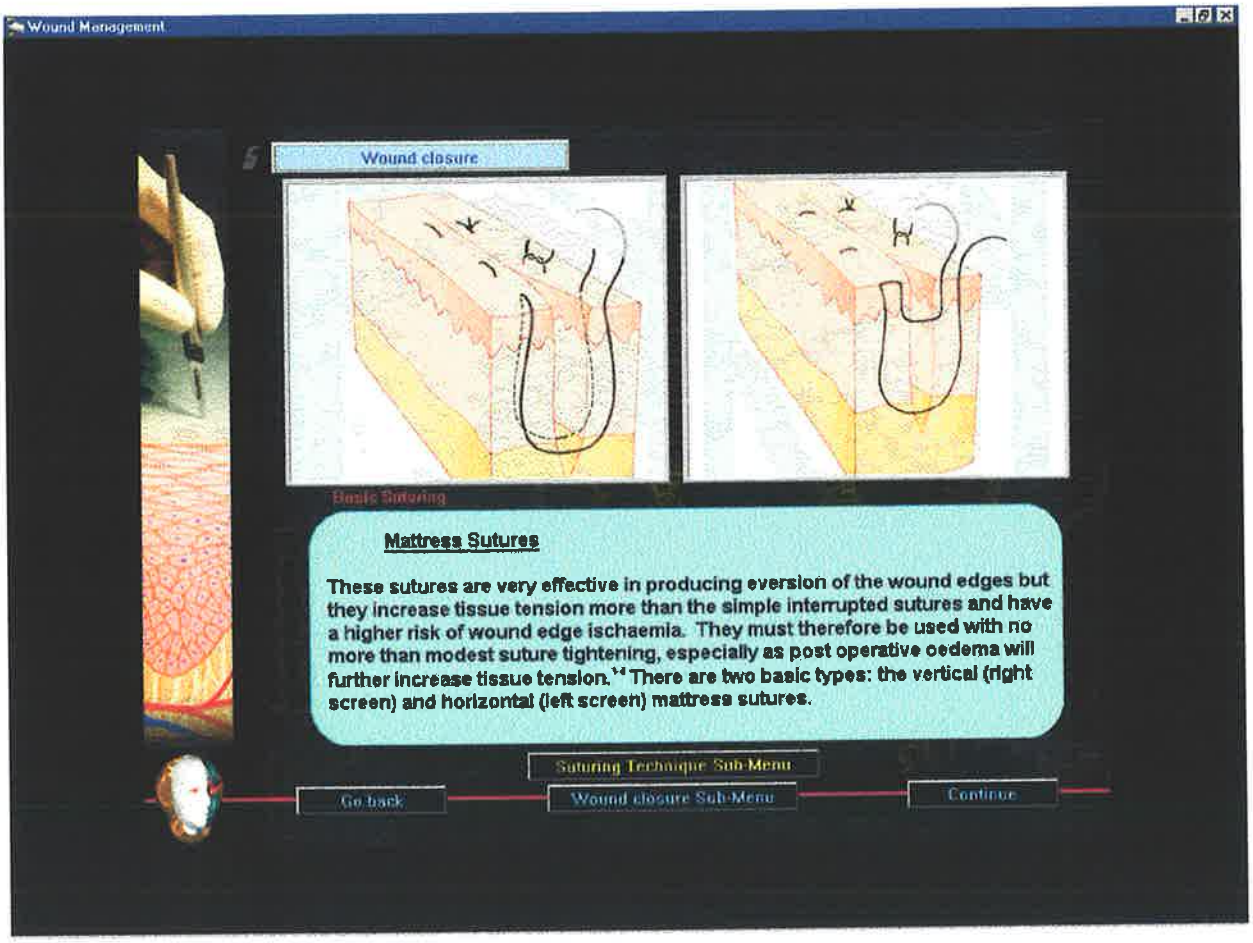
1. The skin is everted and the needle is passed vertically downwards taking a generous bite of dermis (#1).
2. Next the other skin edge is everted and the needle passed from deep to superficial (#2).
3. It is important to take equal vertical heights of tissue so that the wound edges will be matched on tying the suture (#3).
4. Surgeons' knots are tied, then pulled to one side (#4,5). However, if edge eversion is difficult with a single interrupted loop suture then an everting mattress suture may be indicated.

Full Text for the Tenth Page of Suturing Section

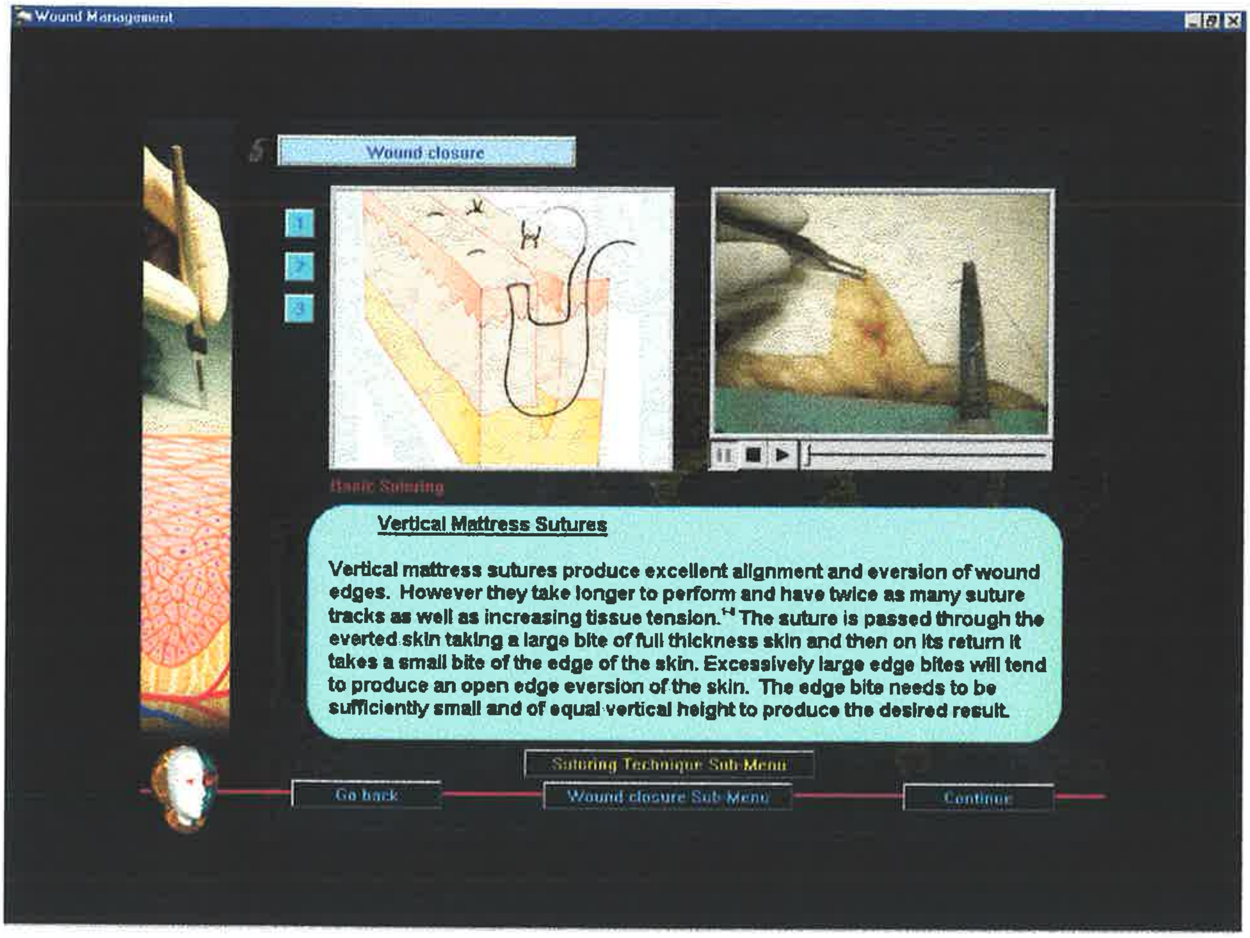
The Horizontal Mattress

Horizontal mattress sutures are also very effective in producing wound edge eversion and are easier to insert. However they produce even greater tissue tension than does the vertical mattress. They must therefore not be excessively tightened.[1-4]

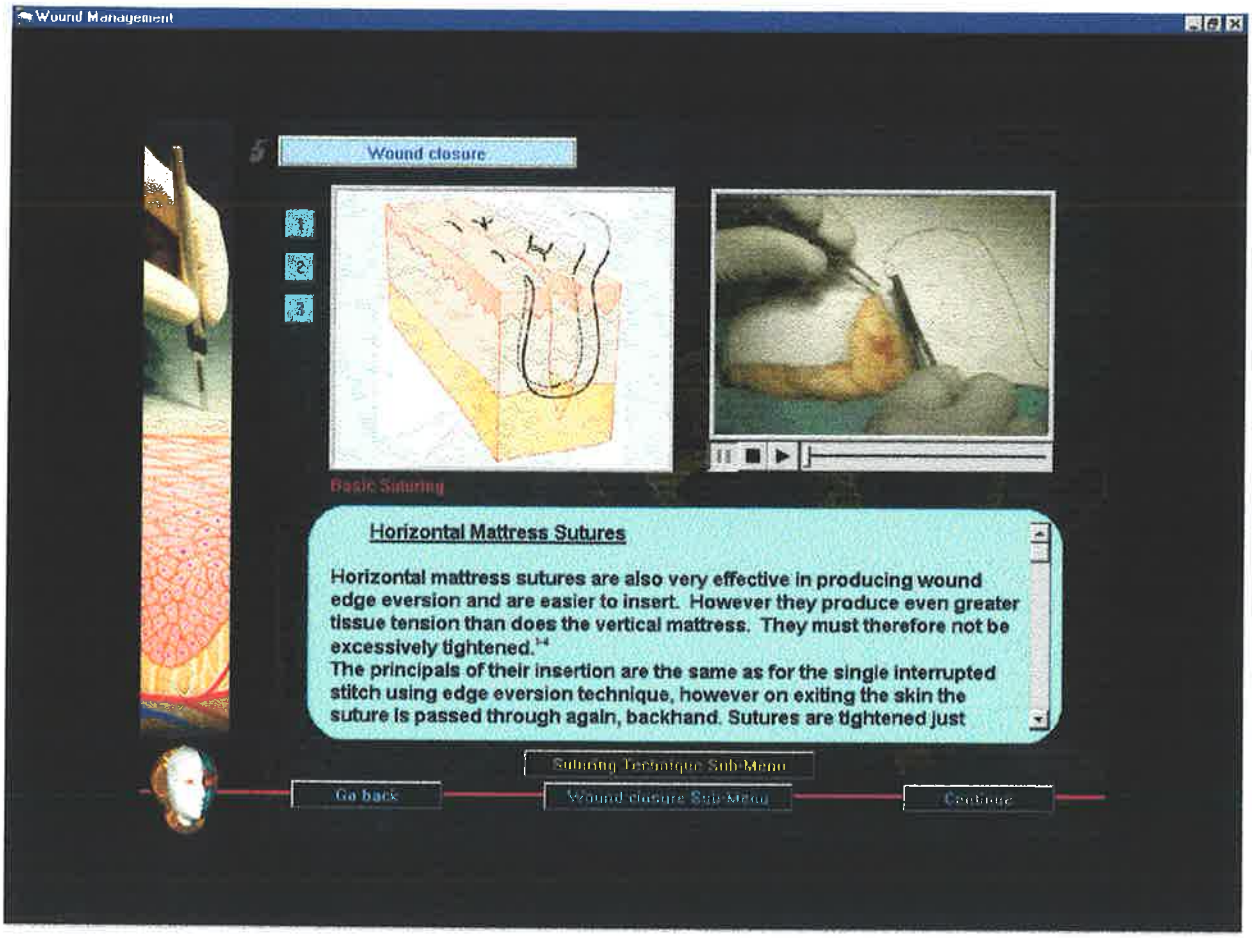
The principals of their insertion are the same as for the single interrupted stitch using edge eversion technique, however on exiting the skin the suture is passed through again, backhand. Sutures are tightened just enough to appose the edges and then tied. Post operative local oedema may make suture removal very difficult. For this reason, a loop mattress may be used.



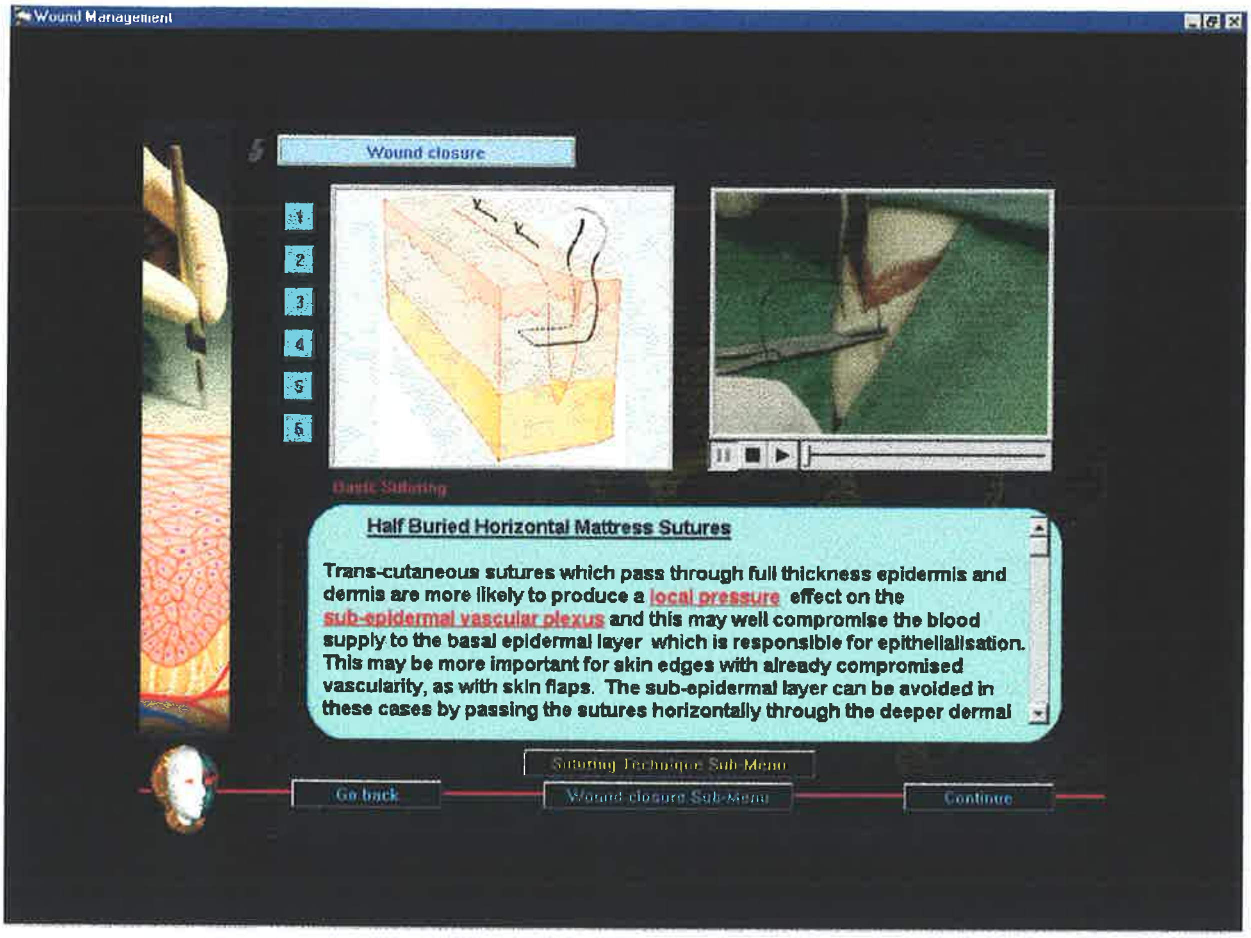
Eigth page of Suturing Section entitled "Mattress Sutures"



Ninth page of Suturing Section entitled "Vertical Mattress Sutures"



Tenth page of Suturing Section entitled "Horizontal Mattress Sutures"

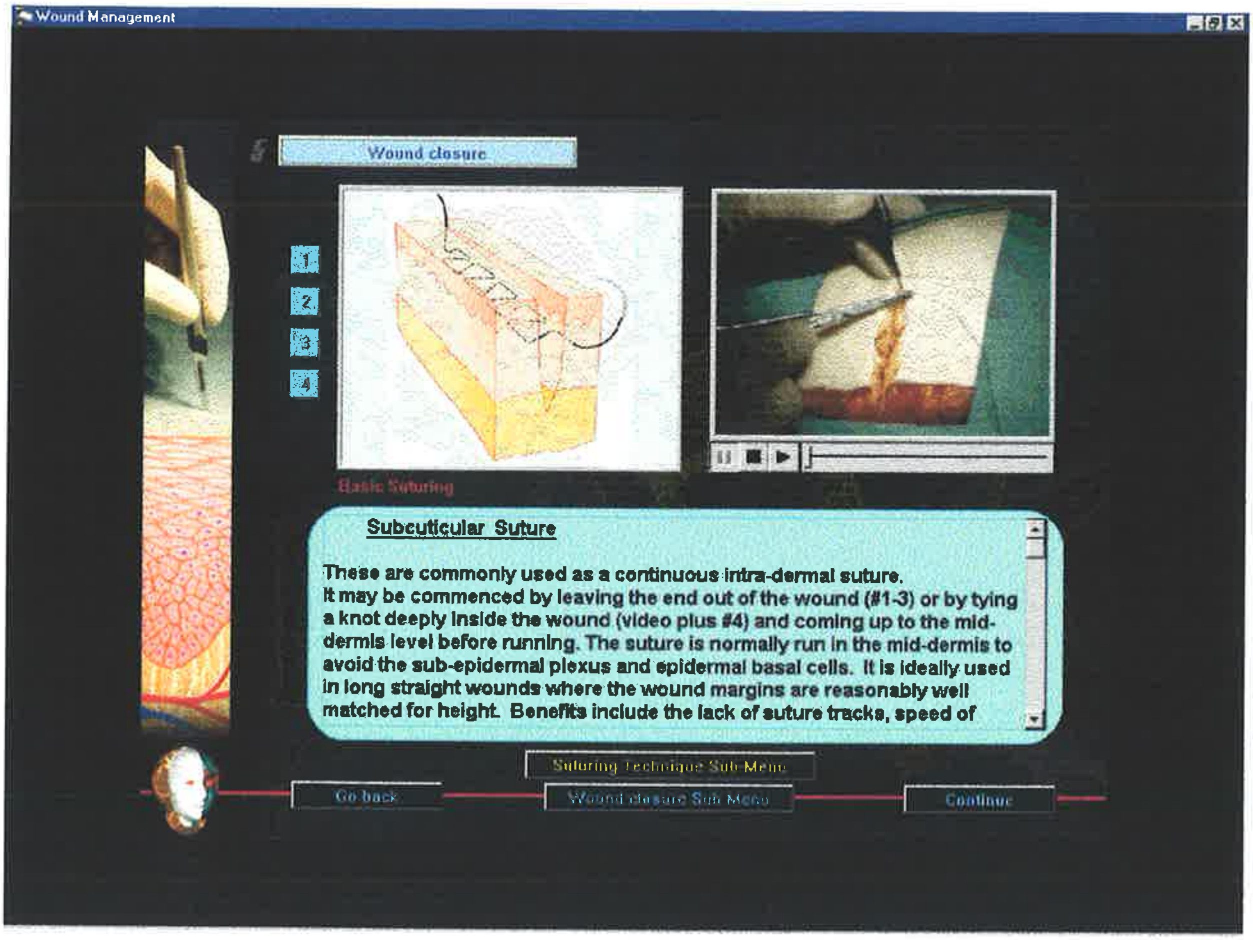


Twelfth page of Suturing Section entitled "Half Buried Horizontal Mattress Sutures"

Full Text for the Twelfth Page of Suturing Section

Half Buried Horizontal Mattress Sutures

Trans-cutaneous sutures which pass through full thickness epidermis and dermis are more likely to produce a local pressure effect on the sub-epidermal vascular plexus and this may well compromise the blood supply to the basal epidermal layer which is responsible for epithelialisation. This may be more important for skin edges with already compromised vascularity, as with skin flaps. The sub-epidermal layer can be avoided in these cases by passing the sutures horizontally through the deeper dermal tissues (#1). These are called the half buried horizontal mattress sutures and may be used in the corner or sides of skin flaps (#2). They are very useful for advancing the tip of a flap into a corner thereby avoiding tip necrosis (#3-6).[3,4] The tip suture is inserted into the deeper dermis only. To avoid placing any constricting trans-cutaneous sutures anywhere near the tip, half buried horizontal mattress sutures are used to secure the nearby edges as well, as seen on the video clip.



Seventeenth page of Suturing Section entitled "Subcuticular Sutures"

Full Text for the Seventeenth Page of Suturing Section

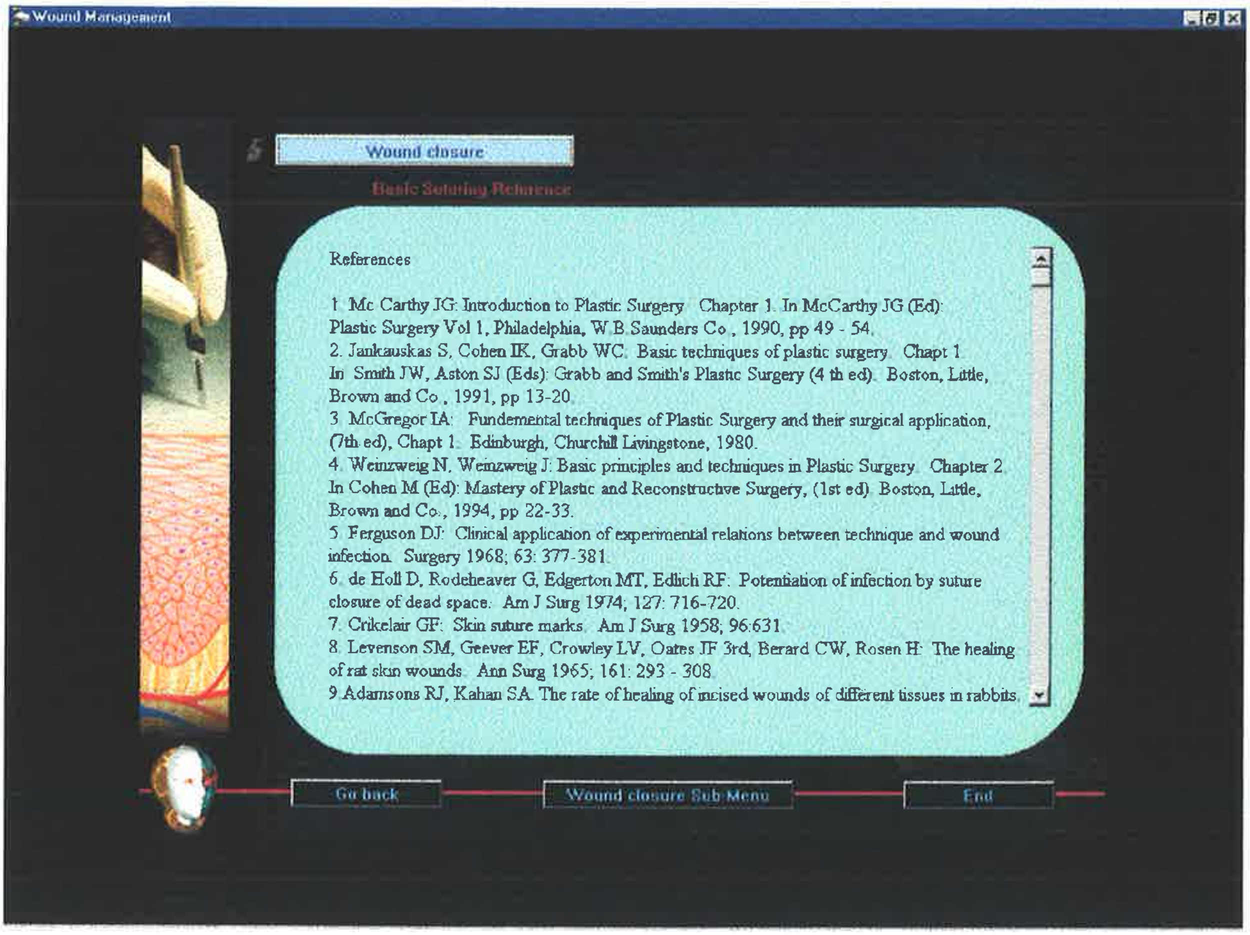
The Subcuticular Suture

These are commonly used as a continuous intra-dermal stitch. It may be commenced by leaving the end out of the wound (#1-3) or by tying a knot deeply inside the wound (video) and coming up to the mid- dermis level before running. The suture is normally run in the mid-dermis to avoid the sub-epidermal plexus and epidermal basal cells. It is ideally used in long straight wounds where the wound margins are reasonably well matched for height. Benefits are; the lack of suture marks, speed of insertion and a reduction in after-care if an absorbable suture is used. Using a slow absorbing stitch with buried knots permits long term support to the wound edges, thus limiting wound stretch and therefore producing finer scars.[4] Mono-filament sutures run more easily through tissue. Larger, stronger sutures are able to take the strain of being pulled through a long length of tissue without breaking.

On completion, the suture may be brought out to the surface and taped securely to the skin. The protruding ends can be trimmed flush one week later. Alternatively, the ends may be tied deeply beneath the dermis and the suture ends trimmed short so they do not protrude through the wound (#4).

Key points on the subcuticular suture technique:

1. star with small equal bites at the wound's end and then take good size bites of equal volume as you progress down the wound
2. the entry point of each stitch should be immediately behind the exit point of the previous stitch, otherwise the wound will gap slightly
3. the suture is run at the same level consistently, otherwise the wound edges will be imperfectly matched
4. if using buried knots be sure to bury them deeply so they can not be felt by the patient or protrude out through the wound edge

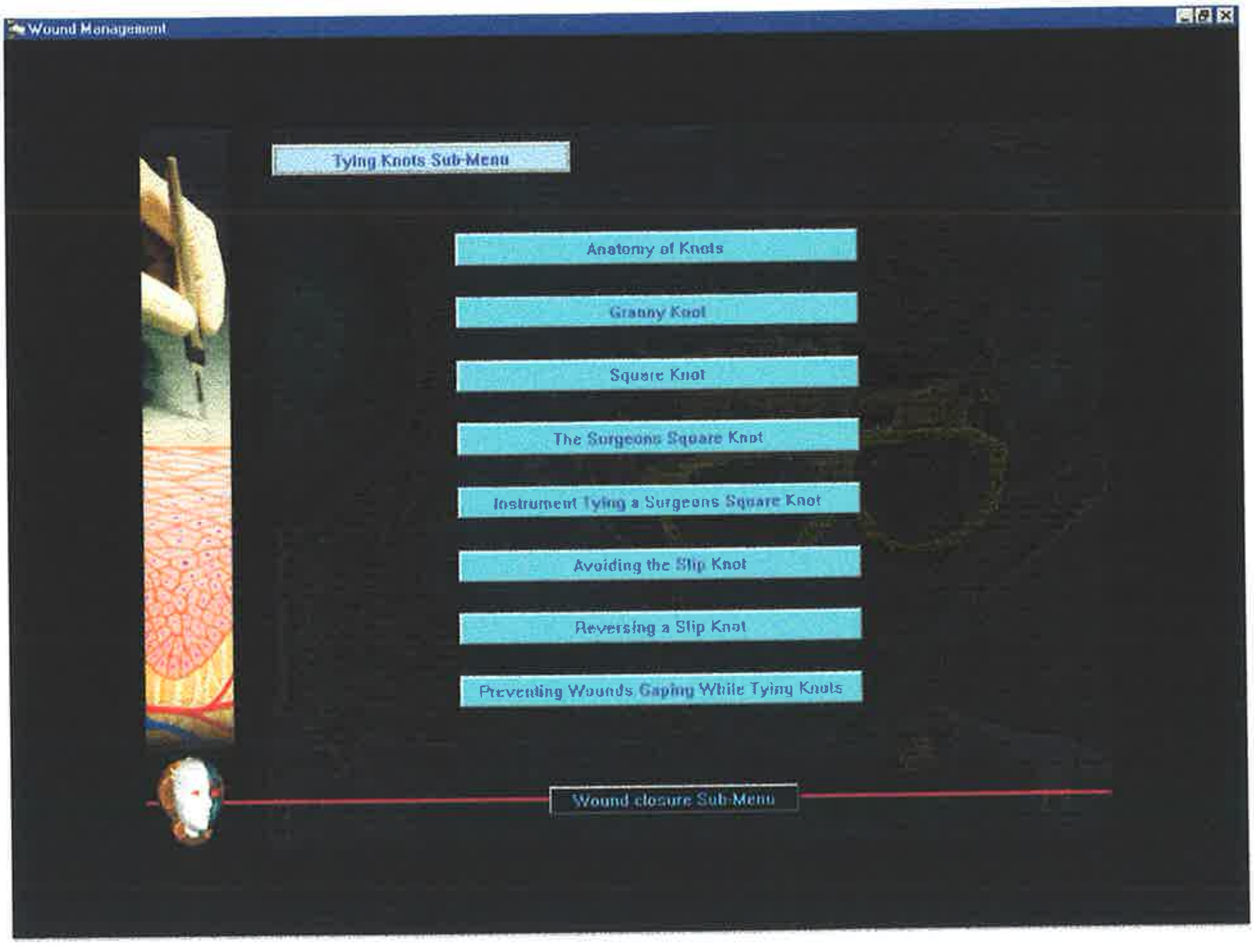


Reference List for Suturing Section

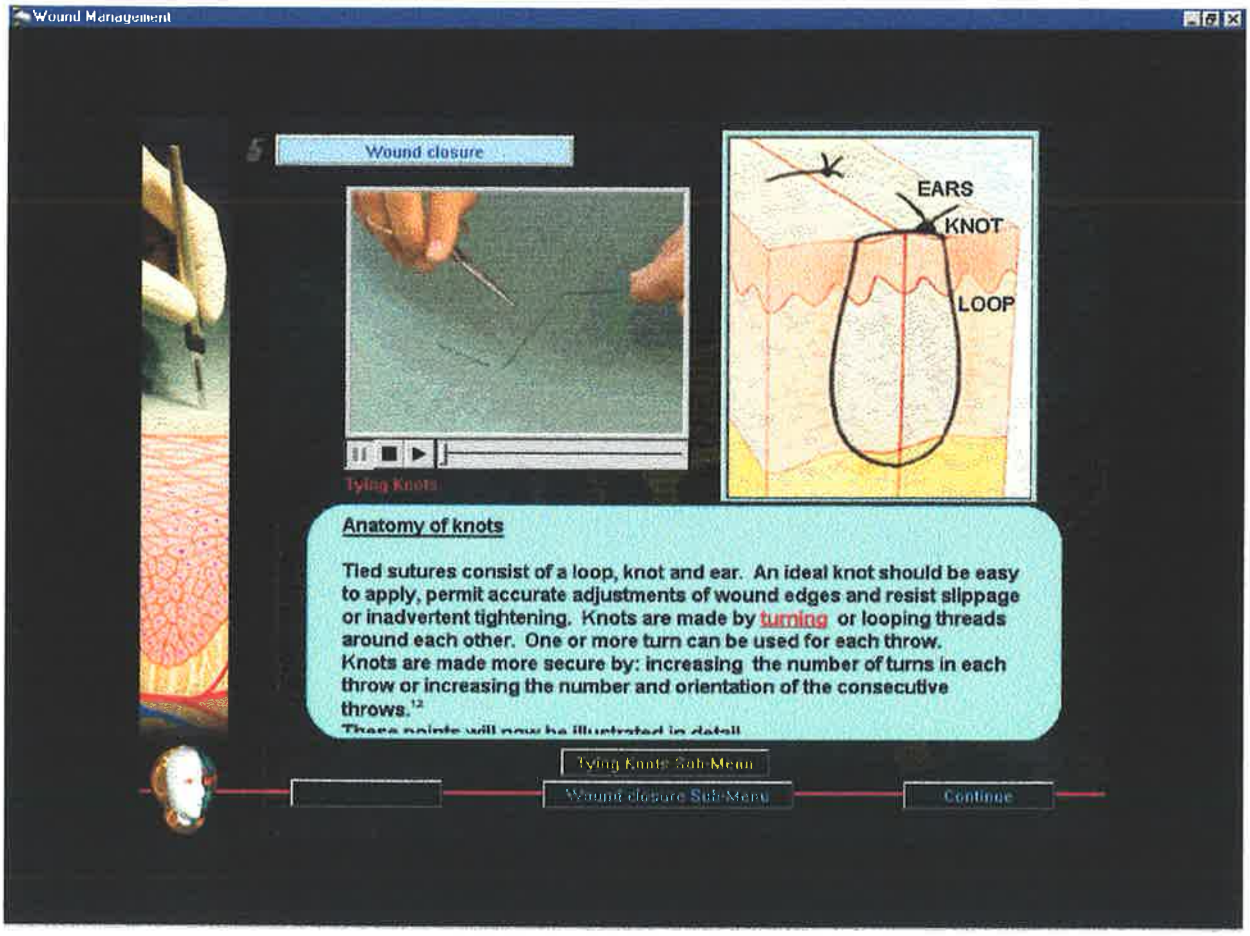
Reference List for the Suturing Section

References

1. Mc Carthy JG. Introduction to Plastic Surgery. Chapter 1. In McCarthy JG (Ed): Plastic Surgery Vol 1, Philadelphia, W.B.Saunders Co., 1990, pp 49 - 54.
2. Jankauskas S, Cohen IK, Grabb WC. Basic techniques of plastic surgery. Chapt 1. In Smith JW, Aston SJ (Eds): Grabb and Smith's Plastic Surgery (4 th ed). Boston, Little, Brown and Co., 1991, pp 13-20.
3. McGregor IA. Fundemental techniques of Plastic Surgery and their surgical application, (7th ed), Chapt 1. Edinburgh, Churchill Livingstone, 1980.
4. Weinzweig N, Weinzweig J. Basic principles and techniques in Plastic Surgery. Chapter 2. In Cohen M (Ed): Mastery of Plastic and Reconstructive Surgery, (1st ed). Boston, Little, Brown and Co., 1994, pp 22-33.
5. Ferguson DJ. Clinical application of experimental relations between technique and wound infection. Surgery 1968; 63: 377-381.
6. de Holl D, Rodeheaver G, Edgerton MT, Edlich RF. Potentiation of infection by suture closure of dead space. Am J Surg 1974; 127: 716-720.
7. Crikelair GF. Skin suture marks. Am J Surg 1958; 96:631.
8. Levenson SM, Geever EF, Crowley LV, Oates JF 3rd, Berard CW, Rosen H. The healing of rat skin wounds. Ann Surg 1965; 161: 293 - 308.
9. Adamsons RJ, Kahan SA,. The rate of healing of incised wounds of different tissues in rabbits. Surg Gynaecol Obstet 1975; 140: 7-12.
10. Botsford TW. The tensile strength of sutured skin wounds during healing. Surg Gynaecol Obstet 1941; 72: 690-697.
11. Nordstrom REA, Nordstrom RM. Absorbable vs non-absorbable sutures to prevent post operative stretching of wound area. Plast Reconstr Surg 1986; 78:186.
12. Emmett AJ, Barron JN. Adhesive suture strip closure of wounds in Plastic Surgery. Br J Plast Surg 1964; 17: 175.
13. Forrester JC. Tape closed and sutured wounds.. Br J Plast Surg 1970; 57: 729.
14. Gault D, Sommerlad B: Suturing skin under tension. PRS 1989; 83: 391.



Sub Menu for the "Tying Knots" Section of Module 5

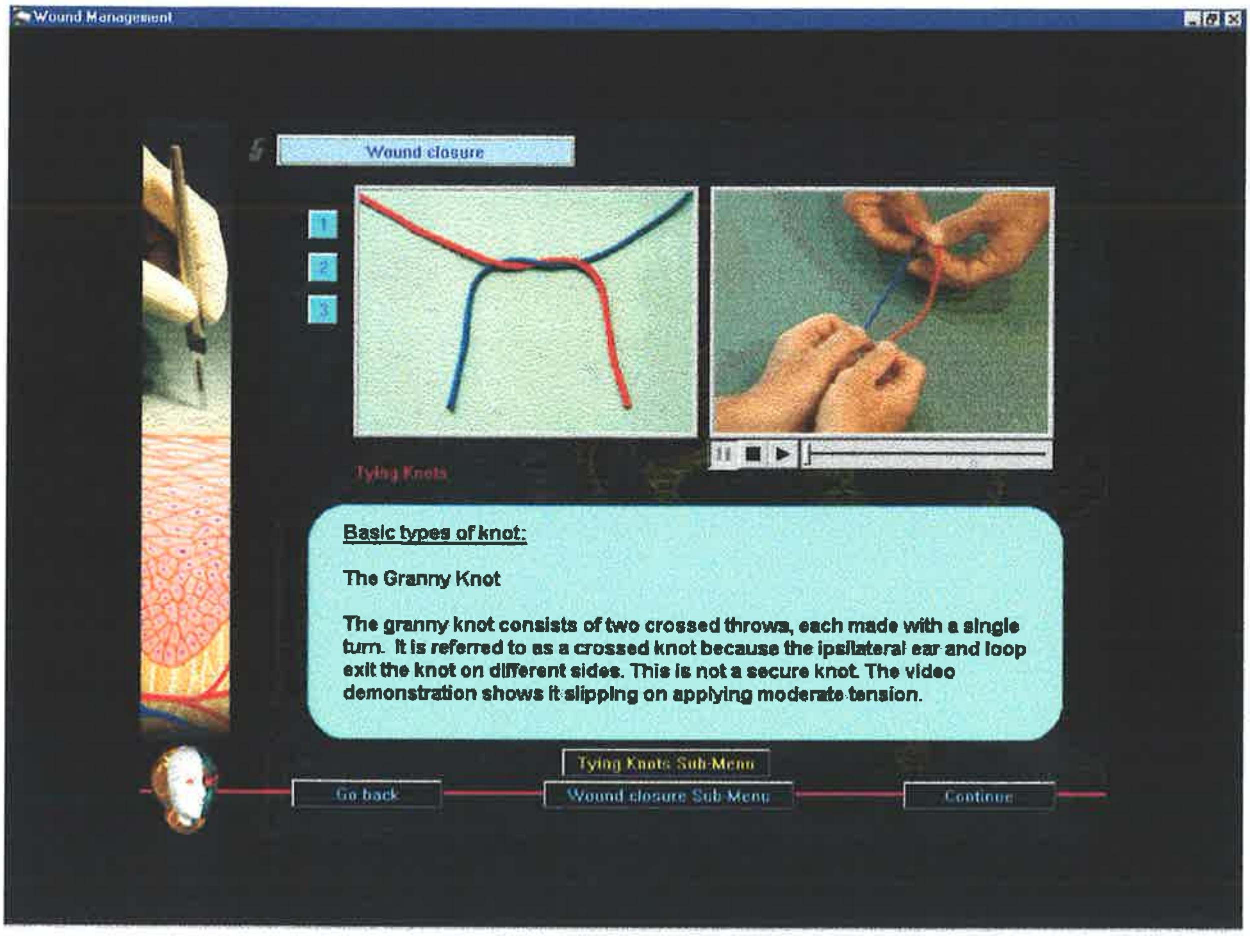


First page of Knot Tying entitled "Anatomy of Knots"

Full Text for the First Page of Knot Tying Section

Anatomy of Knots

Tied sutures consist of a loop, knot and ear (right screen). An ideal knot should be easy to apply, permit accurate adjustments of wound edges and resist slippage or inadvertent tightening. Knots are made by turning *(insert: V3: 10.11 - 11.07, showing the making a turn*) or looping threads around each other. One or more turn can be used for each throw. Knots are made more secure by increasing the number of turns in each throw or increasing the number and orientation of the consecutive throws.[1,2] These points will now be illustrated in detail.

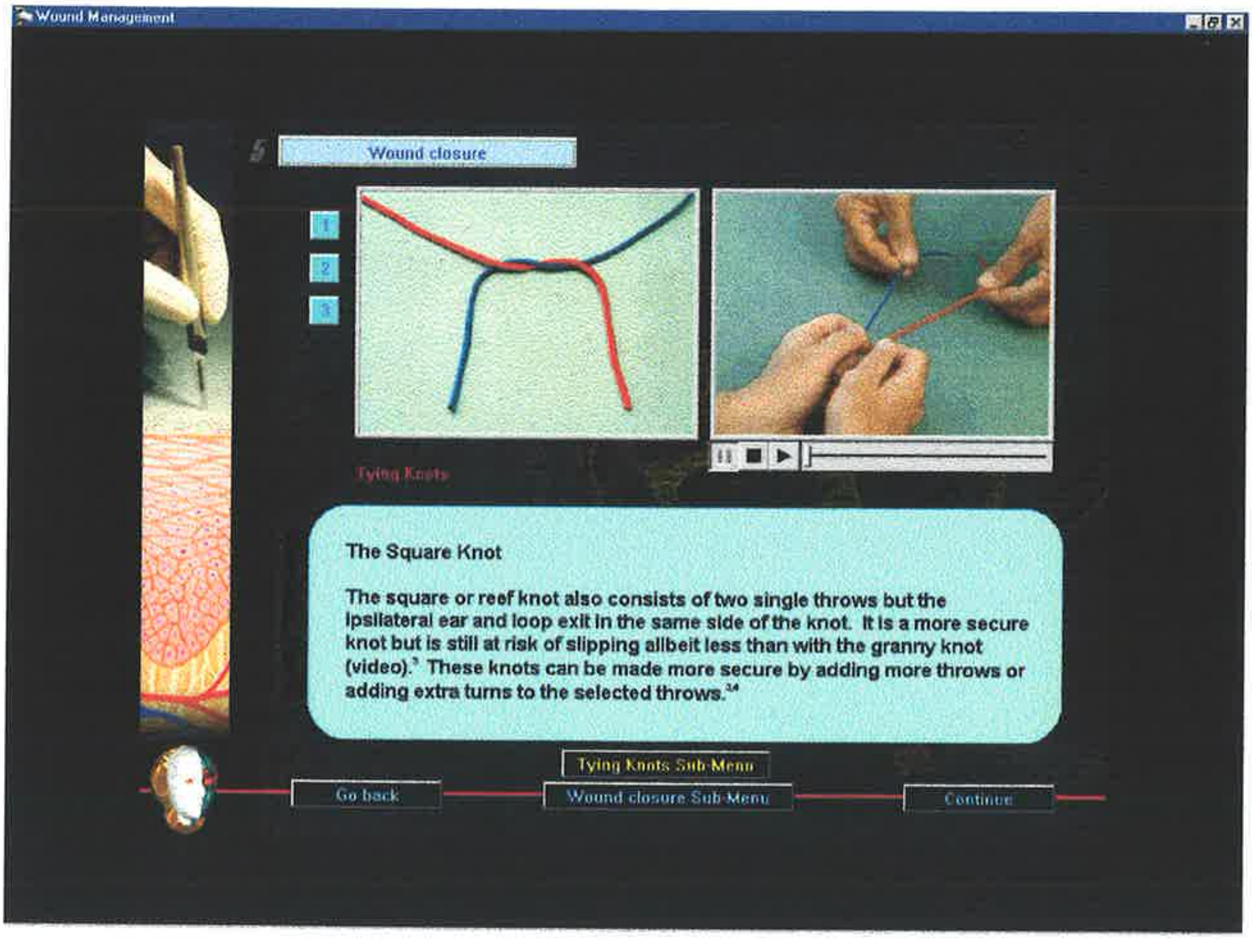


Second page of Knot Tying entitled "The Granny Knot"

Full Text for the Second Page of Knot Tying Section

<u>The Granny Knot</u>

The granny knot consists of two crossed throws, each made with a single turn (#1-3). It is referred to as a crossed knot because the ipsilateral ear and loop exit the knot on different sides. The video shows it slipping on applying moderate tension.

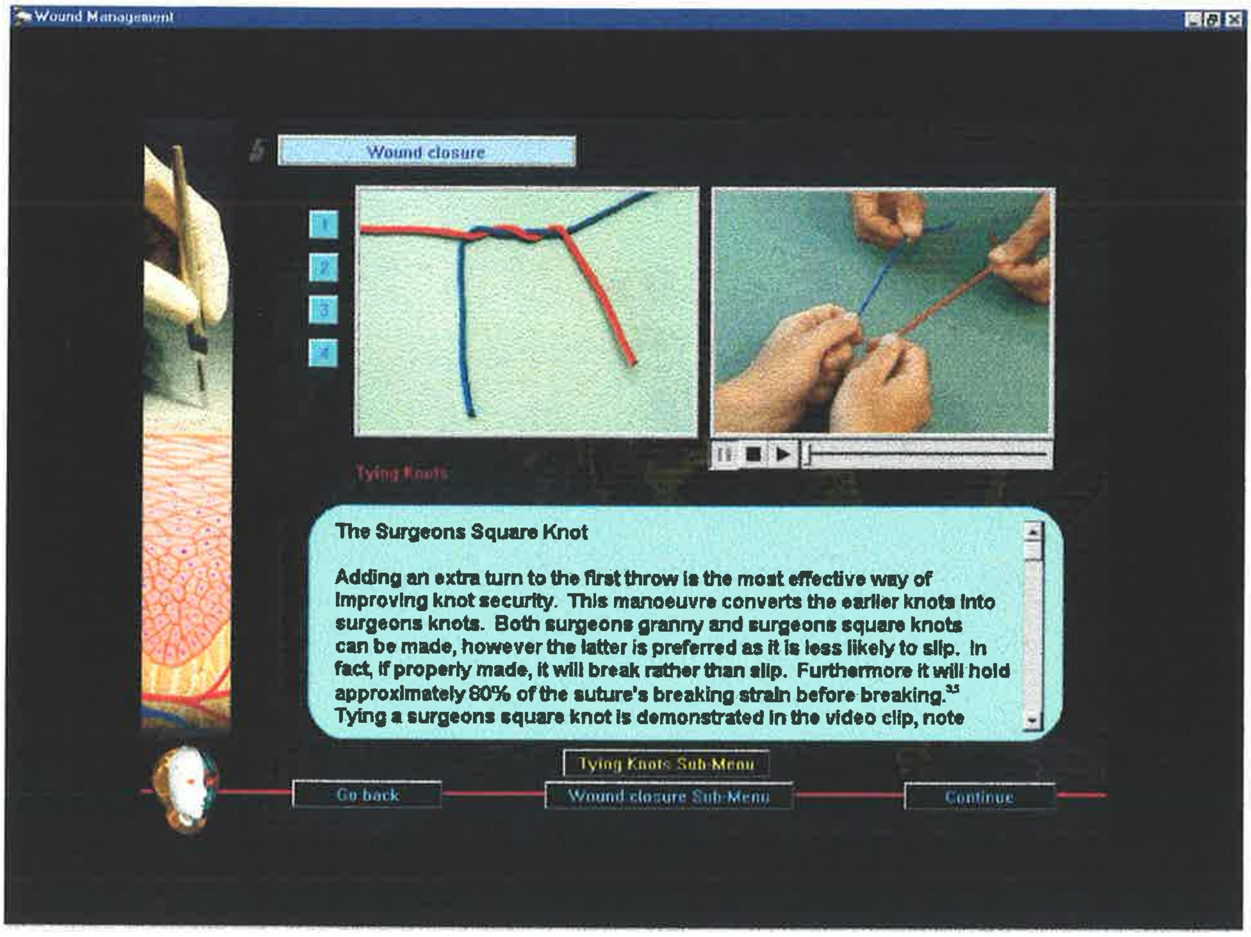


Third page of Knot Tying entitled "The Square Knot"

Full Text for the Third Page of Knot Tying Section

The Square Knot

The square or reef knot also consists of two single throws, but the ipsilateral ear and loop exit in the same side of the knot (#1-3). It is a more secure knot, but is still at risk of slipping albeit less than with the granny knot, as is demonstrated on the video.[3] These knots can be made more secure by adding more throws or adding extra turns to the selected throws.[3,4]

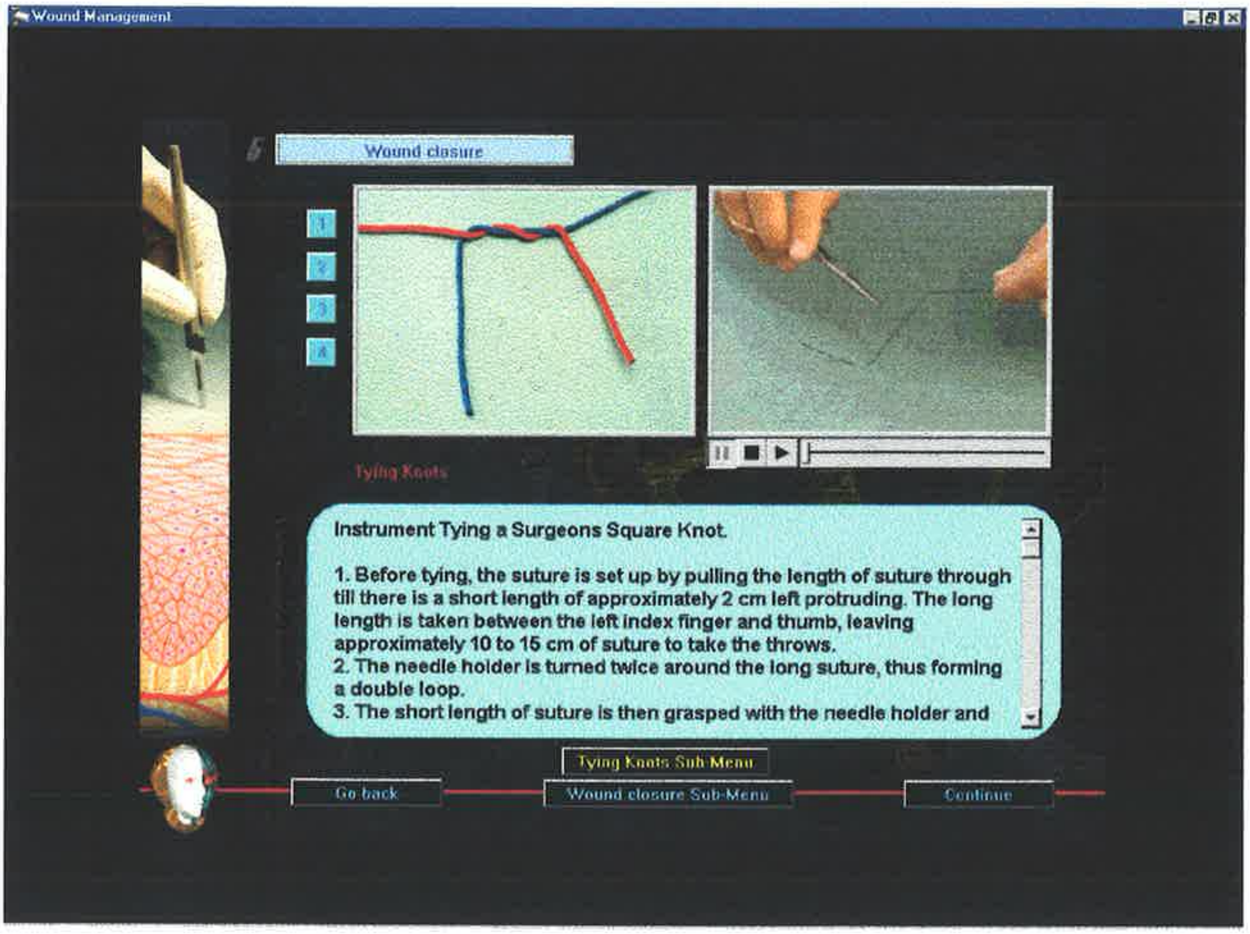


Fourth page of Knot Tying entitled "The Surgeon's Square Knot"

Full text for the Fourth Page of the Knot Tying Section

The Surgeons Square Knot

Adding an extra turn to the first throw is the most effective way of improving knot security. This manoeuvre converts the earlier knots into surgeons knots. Both surgeons granny and surgeons square knots can be made, however the latter is preferred as it is less likely to slip. In fact, if properly made, it will break rather than slip. Furthermore it will hold approximately 80% of the suture's breaking strain before breaking.[3,5] Tying a surgeons square knot is demonstrated in the video clip, note the lack of slippage even on applying marked tension.

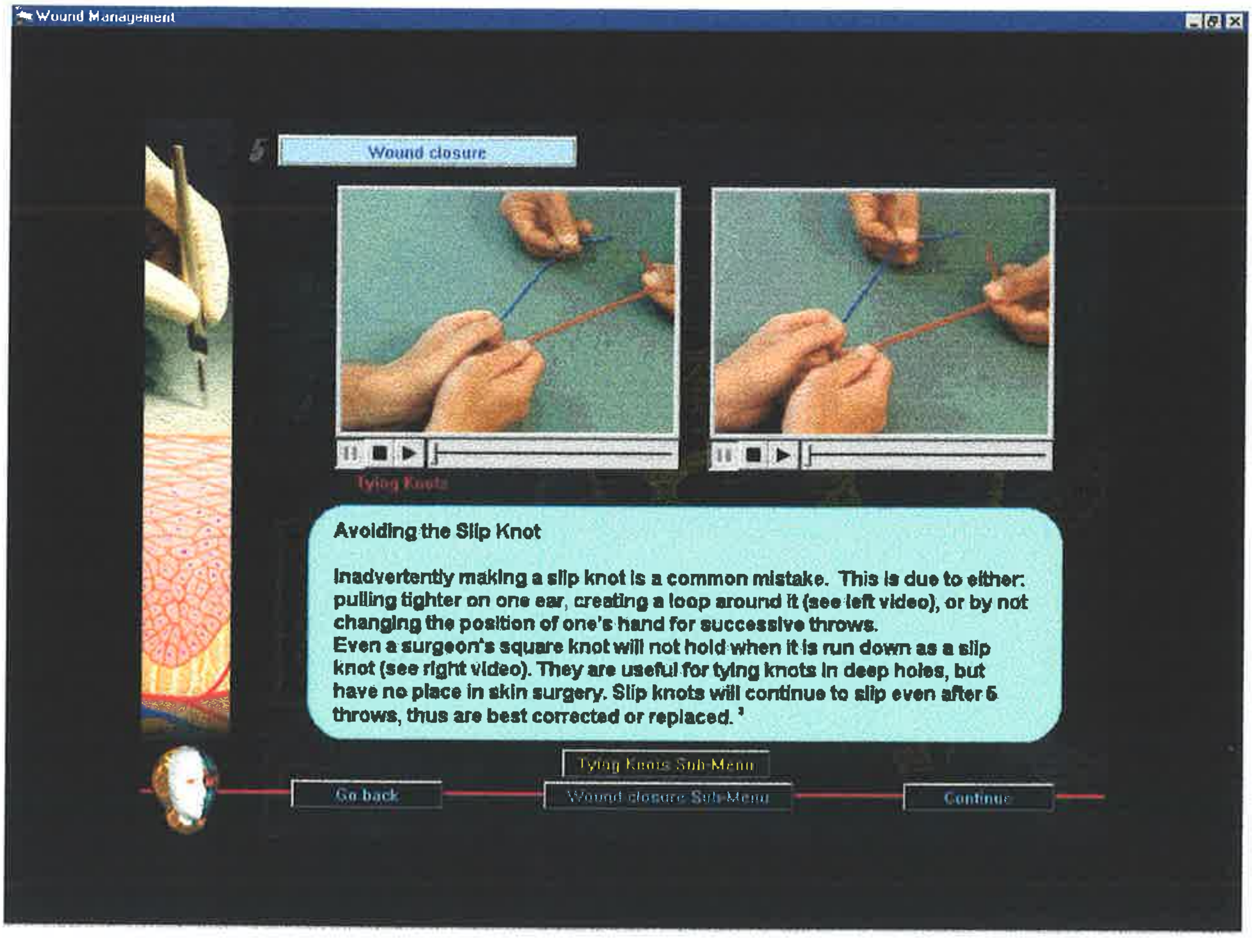


Fifth page of Knot Tying entitled "Instrument Tying a Surgeon's Square Knot"

Full Text For Fifth Page of Knot Tying Section

Instrument Tying a Surgeons Square Knot

1. Before tying, the suture is set up by pulling the length of suture through till there is a short length of approximately 2 cm left protruding. The long length is taken between the left index finger and thumb, leaving approximately 10 to 15 cm of suture to take the throws.
2. The needle holder is turned twice around the long suture, thus forming a double loop.
3. The short length of suture is then grasped with the needle holder and pulled through the loops, across the wound. The suture is tightened just enough to appose the wound margins, without strangulation. Single turn throws tend to slip whereas double turn throws tend to hold suture tension long enough for the subsequent locking throw to be placed.
4. The second throw has a single turn, but it is done in the opposite direction to the first. On viewing the video segment, you will see that the first throw is done by placing the needle holder on the inside edge of the long suture to make the turns. For the second throw, the needle holder is placed on the outside edge of the long length, ie. the opposite side. Failure to do this results in a surgeon's granny knot. By pulling the short length back across the wound margin, the knot sits square and can then be tightened.
5. Tightening the second throw completes the knot, however a third, single, reversed throw is commonly used for added security. This is usually for holding smooth monofilament sutures, which slip more easily.[4] Knots are pulled to one side and the ends trimmed. Leaving some length prevents knots untying due to slippage. They are cut to be just short of the distance to the next knot, at least 3 mm. Trimming avoids entanglements while tying the next knot. The exception to this is for the buried knots which are cut short to prevent them protruding from the wound margin.[1-3]



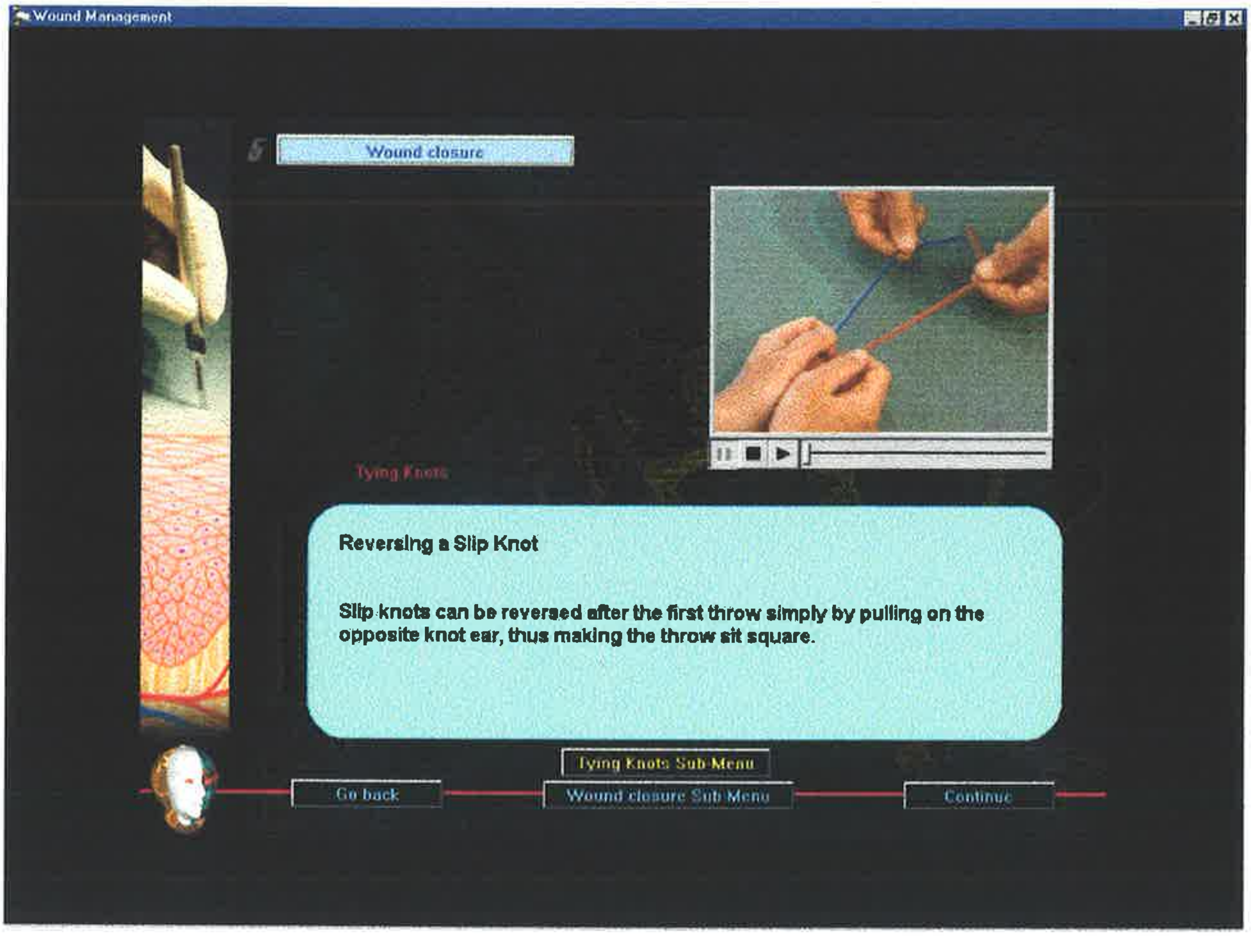
Sixth page of Knot Tying entitled "Avoiding the Slip Knot"

Full Text for the Sixth Page of Knot Tying Section

Avoiding the Slip Knot

Inadvertently making a slip knot is a common mistake. This is due to either pulling tighter on one ear, creating a loop around it, or by not changing the position of one's hand for successive throws. The left video shows a square knot run down as a slip knot. Even a surgeon's square knot will not hold when it is run down as a slip knot. This is well demonstrated on the right video.

Slip knots are useful for tying knots in deep holes, but normally have no place in skin surgery. Slip knots will continue to slip even after 5 throws, they are therefore are best avoided. [2]

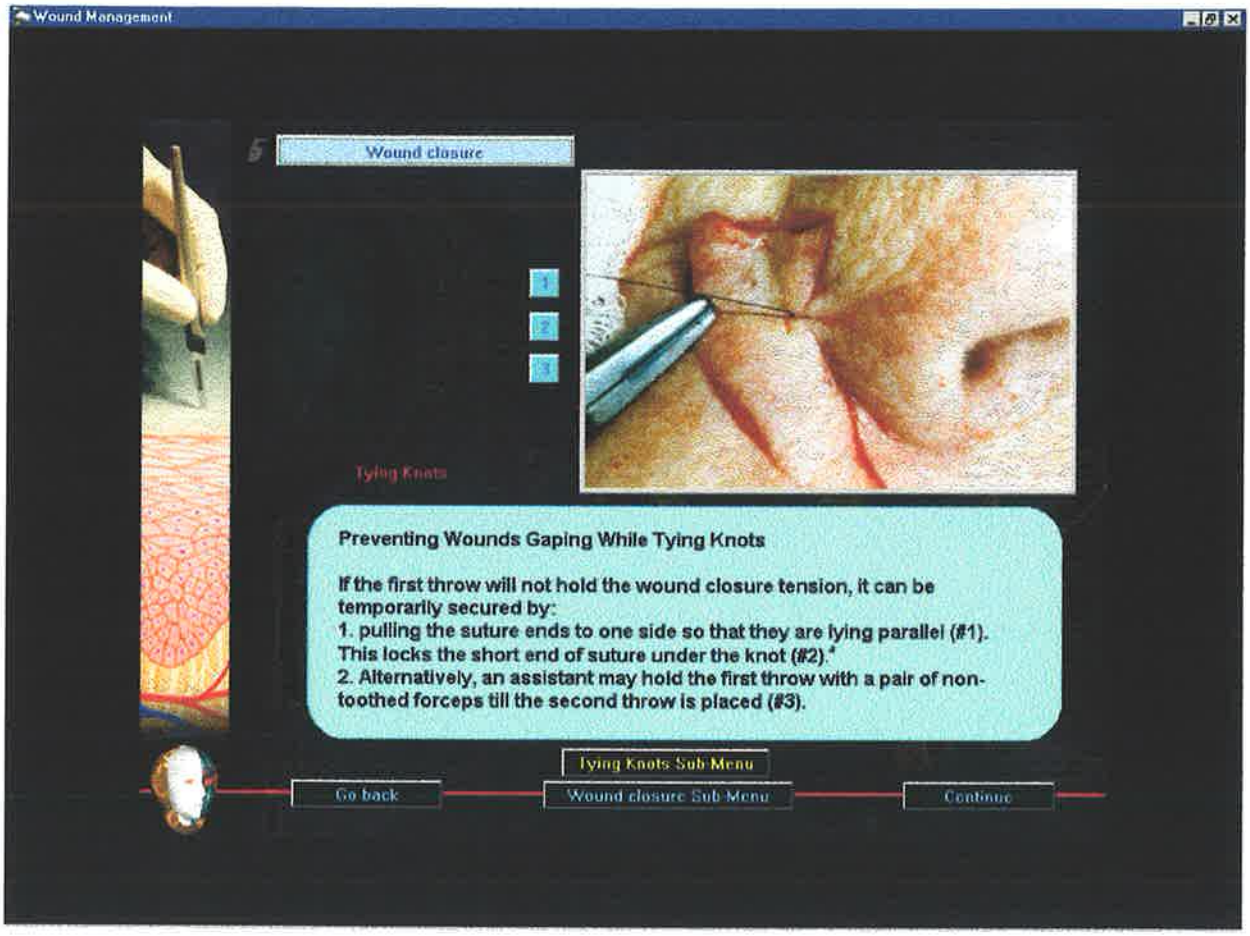


Seventh page of Knot Tying entitled "Reversing a Slip Knot"

Full Text for the Seventh Page of Knot Tying Section

Reversing a Slip Knot

Slip knots can be reversed after the first throw by pulling on the opposite knot ear, thus making the throw sit square. The video demonstrates a slip knot which was reversed and then tied as a proper square knot. Note how secure the final knot is, the assistant can no longer pull the cord through the knot.



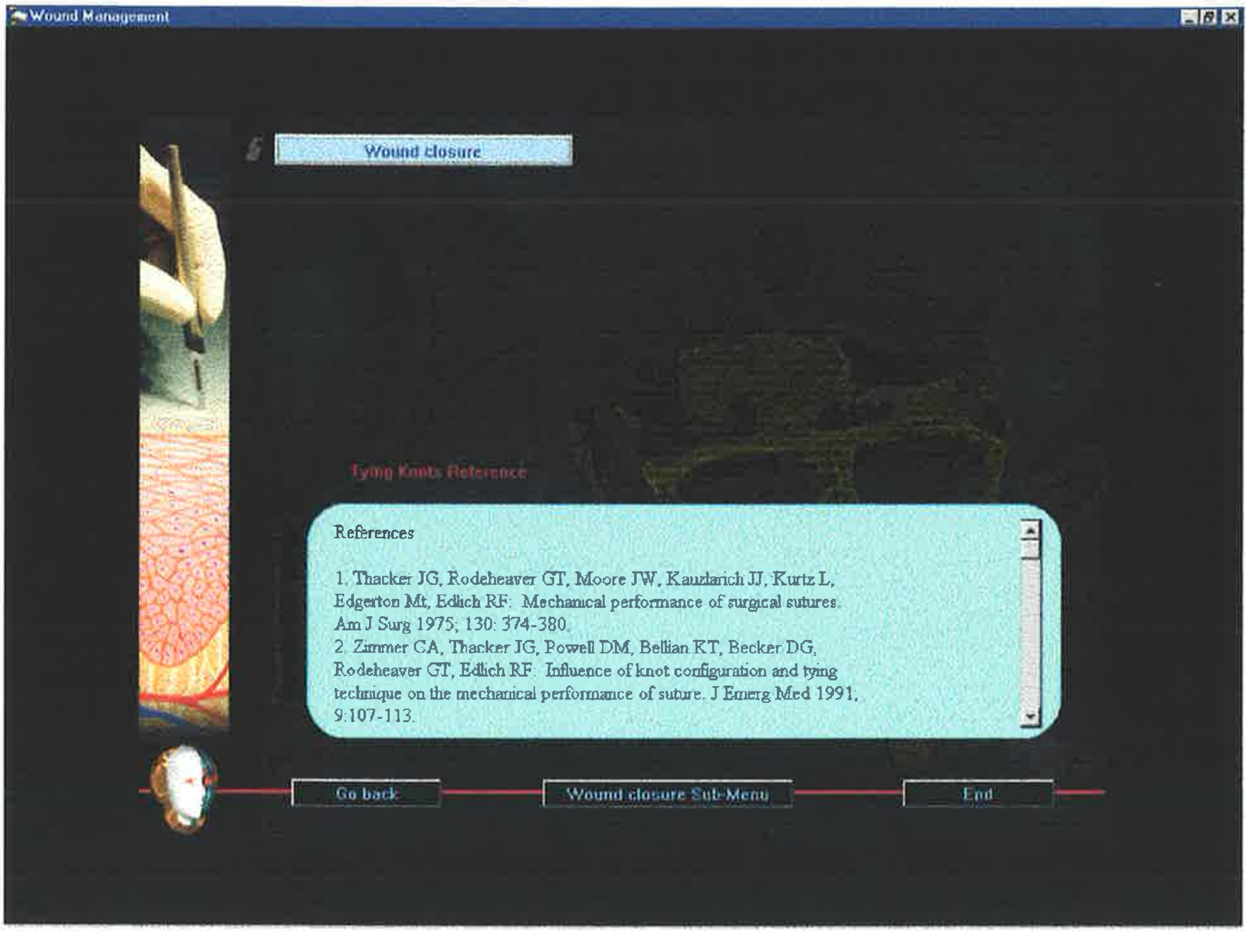
Eigth page of Knot Tying entitled "Preventing Wounds Gaping While Tying Knots"

Full Text for the Ninth Page of Knot Tying Section

Preventing Wounds Gaping While Tying Knots

If the first throw will not hold the wound closure tension, it can be temporarily secured by:

1. Pulling the suture ends to one side so that they are lying parallel. This locks the short end of suture under the knot (#1- 3).[4]
2. Having the assistant hold the first throw with a pair of non-toothed forceps until the second throw is placed (#4).



Reference List for the Knot Tying Section of Module 5

Full Text for the Tenth Page of Knot Tying Section

References

1. Thacker JG, Rodeheaver GT, Moore JW, Kauzlarich JJ, Kurtz L, Edgerton Mt, Edlich RF. Mechanical performance of surgical sutures. Am J Surg 1975; 130: 374-380.
2. Zimmer CA, Thacker JG, Powell DM, Bellian KT, Becker DG, Rodeheaver GT, Edlich RF. Influence of knot configuration and tying technique on the mechanical performance of suture. J Emerg Med 1991; 9:107-113.
3. Edlich RF. USSC surgical knot tying manual. Norwalk, USSC, 1993.
4. Holmlund DEW. Knot properties of surgical suture materials. A model study. Acta Chir Scand 1974; 140: 355.
5. Herrmann JB. Changes in tensile strength and knot security of surgical sutures in vivo. Arch Surg 1973; 106: 708.

APPENDIX C

THE TEST: USED FOR PRE-TEST, POST-TEST 1 AND 2

Types of Wound Closure, 1^0, 2^0, 3^0 & Regenerative

1. Q: How soon must a wound be closed to be classified as primary closure? — 1 mark for either

   A: immediately / within 48 hours

2. Q: These wounds are said to heal by primary intention.

   A distinguishing feature of this is that the epidermis heals by …… — 1 mark

   A: direct epithelisation

3. Q: two main benefits of primary over secondary closure, in relation to time to healing and scar formation are: — 1 mark each max - 2

   A: a)faster healing. b)less scar

4. Q: wounds which are too oedematous for immediate closure can be closed after this has subsided. This usually occurs at 48-72 hours and is called………? — 1 mark

   A: delayed primary closure

5. Q: Under which 2 general conditions may secondary closure be acceptable first option? — 1 mark each an max -2

   A: a) too large a skin deficit to close directly

   b) wound not clean/not adequately debrided / non-viable tissue present

6. Q: Give 2 clinical examples where secondary closure is a recognised, popular technique for closing a wound. — 1 mark either max - 2

   A: leg ulcers, finger-tips.

7. Q: Tertiary closure is different to delayed primary closure by the fact that wounds closed by the former are allowed to partly close with .... tissue prior to being surgically closed. — 1 mark

A: granulation

8. Q: Tertiary closure has been popular for the surgical management of which wounds? (list 2) — 1 mark each, max - 2

A: a) deeply contaminated, b) devitalised c) war wounds

9. Q: Superficial skin wounds eg abrasions/shallow burns, heal by.....? — 1 mark

A: epithelial regeneration

Wound Handling & Suturing

10. Q: Following adequate wound preparation, good 1^0 wound closure technique requires: — 1 mark each, max - 3

A: a) atraumatic tissue handling

b)accurate wound edge apposition

c)minimal wound tension

11. Q: Tissue ischaemia due to excessive tension of wound closure results in: (3 points) — 1 mark each, max - 3

A: a) increased infection risk b) delayed healing, c) poorer scar result

12. Q: Skin wound margin may be mobilised by which surgical manoeuvre? — 1 mark

A: undermining

13. Q: What 2 immediate, undesirable conditions does wound edge undermining have? — 1 mark each, max - 2

A: reduces local blood supply, creates potential dead space

14. Q: Gaping wounds require a certain amount of suture tension to close. High suture tension compromises wound healing. List 4 ways that the selection and placement of sutures may minimise this. — 1 mark each, max - 4

a) larger suture loops or place them further from edge
b) avoid mattress or running sutures
c) include a greater volume of dermis in suture loop
d) place dermal sutures first, to take tension

15. Q: Why are suture knots best placed to one side of a wound margin? — 1 mark

A: a)tension greater under knot, therefore avoid on flaps/grafts
b)easier suture removal, otherwise knot gets meshed in wound's scab

16. Q: How do you determine how long to cut suture ends? — 1 mark

A: just short of length to next suture site or at least 3mm

17. Q: What type of scar can you expect if you fail to evert the wound edges? — 1 mark

A: depressed

18. Q: this occurs due to the process of scar ....? — 1 mark

A: contracture

19. Q: List 4 undesirable features which result from inaccurate wound closure? — 1 mark each, max - 4

A: a) dead space
b) gaping wound
c) misaligned margins
d) more scar

20. Q: How do suture sinus tracks occur? — 1 mark

A: epithelisation of suture track

21. Q: Permanent suture tracks will form in almost all wound if the sutures are left in longer than ....days — 1 mark

A: 14

22. Q: To avoid this, transcutaneous sutures should be removed by .....days. — 1 mark

A: 7 or 10

23. Q: Wound tensile strength at 7 days is approximately ...% of normal skin — 1 mark

A: 5%

24. Q: Removal of sutures at 7 days from a site subject to high static tension may result in some degree of wound............? — 1 mark

A: dehiscence

25. Q: Additional long term wound support is possible with the use of...? (list 2 methods) — 1 mark each, max - 2

A: a) buried dermal sutures

b) skin tape

26. Q: What beneficial effect on final scar outcome does long term wound support have? — 1 mark,

A: finer, less scar, better.

27. Q: List 5 potential complications resulting from the creation of wound dead space. — 1 mark each, max - 5

A: a) haematoma

b) seroma

c) infection

d) delayed healing

e) extra scar

28. Q: Which type of suture is renown for producing wound edge eversion? — 1 mark

A: mattresses

29. Q: How many turns in the first throw of a surgeon's square knot? 1 mark

A: 2

30. Q: Why are extra turns put is some knots? 1 mark

A: extra security / reduce slip

31. Q: What is the benefit of adding extra throws to a knot? 1 mark

A: extra security / reduce slip

32. Q: What percentage of a suture's breaking strain will a surgeon's square knot hold before itself breaking. 1 mark

A: 80%

33. Q: After how many throws will a slip knot become a reliable knot, if at all? 1 mark

A: does not become secure, even after 8 throws

34. Q: What haemodynamic effect is more pronounced with mattress rather than the single interrupted sutures? 1 mark

A: local ischaemia

OSCI stations

1. Using the suture and needle holder provided, place the following types of suture loops in the simulated wound:
    a. single interrupted loop
    b. vertical mattress
    c. horizontal mattress
    d. corner stitch

Each suture marked for:

A) correct placement - 2. B) symmetry - 2. C) everting wound edge - 2.

total - 6 marks each

2. Using the coloured cords provided, tie the following knots:

a. square knot

b. surgeon's square knot, with 2 throws only

c. slip knot with 2 throws

each knot marked:

square = 2, surgeon's square = 4, slip = 3

Total marks = Questions (55) + OSCI (39) = 104