

**BIOENGINEERING DIVISION
DEPARTMENT OF MEDICAL PHYSICS
ROYAL PERTH HOSPITAL**

Briefing notes for posts within the Bioengineering Division
Dated: June 2002

PERTH, WESTERN AUSTRALIA

Perth, the capital city of Western Australia, is situated on the Swan River approximately 12 km. from the coast. The greater metropolitan area includes the port city of Fremantle at the head of the river and extends approximately 25km north and south along the coastal strip. Perth has a population of 1.38 million, comprising approximately 60% of the total population of Western Australia and as such, is the hub of the majority of professional, commercial and industrial activities in WA. WA has an area in excess of 25 million sq.km.; approximately one third of the area of Australia and extending north across three climatic zones.

Perth has a temperate climate, often described as Mediterranean, with average temperatures in the range 8 – 30 deg.C. The climate and the proximity with the river and the extensive beaches along the west coast, places an emphasis on outdoor and water recreation. Typically, restaurant and cafe dining is alfresco and entertaining is centred on the home.



Perth has a comprehensive public transport system based on both bus and rail systems. Currently the eastern, south-eastern and northern corridors are serviced by an electric rail system fed by local bus networks and plans are current to extend this to include the southern coastal corridor. Like most of Australia, WA is strongly reliant on the automobile and Perth is well served by a quality freeway and secondary road network. Typically, most places in the greater metropolitan area are within 30 minutes travel from the CBD. Royal Perth Hospital, for example, is served by both rail and bus systems.

Western Australia has a respected primary, secondary and tertiary education sector with a combination of public and private education options. Perth is the centre for five Universities; the University of Western Australia, Curtin University of Technology, Murdoch University, Edith Cowan University and Notre Dame in Fremantle. University education is complemented by an extensive network of metropolitan and regional colleges of TAFE which provide training from trade to pre-degree level.

Perth is well linked to regional centres in WA, the other states of Australia, south-east Asia and international destinations, by both domestic and international airlines.

ROYAL PERTH HOSPITAL:

Royal Perth Hospital (RPH) is Western Australia's premier teaching Hospital, providing a comprehensive range of emergency and elective services for adults and serving as a State referral centre for many specialist areas in both medicine and surgery. The 955 bed Hospital is organised across two sites; the Wellington St Campus (WSC - 694 beds) on Wellington St in the CBD and the Shenton Park Campus (SPC – 261 beds).



As one of the largest employers in WA, the Hospital employs the equivalent of 3849 full time employees in a wide range of occupations. It admits more than 78000 patients per annum and has a total annual operating budget in excess of \$305 million.

The Hospital has close affiliations with the University of WA's Schools of Medicine and Surgery and with other Institutions involved with research and in the education of nursing and allied health professionals. Research is an integral part of ongoing activities and staff of RPH make a significant contribution to national and international understanding of the prevention, diagnosis and the treatment of disease through participation in conferences and their contribution to the literature.

DEPARTMENT OF MEDICAL PHYSICS:

The Department of Medical Physics represents a number of professional interests required for the provision of physics, science, engineering and technology services to the staff and the patients of the Hospital. In addition to the Bioengineering Division, the Department represents the;

- Clinical Physics Division, providing medical physics support to radiotherapy, brachytherapy, imaging (incl. diagnostic radiology) laser technology and laboratory services in the Hospitals and to private practices in the region
- Technical Services Division, providing biomedical engineering (incl. clinical engineering) services related to the management, evaluation, service / maintenance and development of electromedical, laboratory and surgical equipment in the Hospital.
- Scientific Computing Division, providing software support, the organisation and maintenance of computing resources within the Department, mathematics and statistics support to the Hospital.

The Department reports directly to the Clinical Divisions of the Hospital, which in turn report to the Executive. At RPH (WSC) the link is to the Surgical Specialties Division, while at SPC responsibility is to the Rehabilitation & Elective Orthopaedics Division. Bioengineering Division is responsible to both these areas.

BIOENGINEERING DIVISION:

The Bioengineering Division of the Department of Medical Physics, Royal Perth Hospital (RPH), provides a specialist professional service to the Hospital, the Clinicians and the community of Western Australia in the areas of Bioengineering and Rehabilitation Technology.

(Refer: Divisional organisation chart on page 2, for information)

Bioengineering provides services from facilities in the Department of Medical Physics (Level 1, North Block) on the Wellington Street Campus (WSC) of RPH, sited approximately four blocks to the east of the CBD. The Hospital is convenient to public transport (bus and rail).

The Bioengineering group provides a comprehensive range of services to the Hospital including a particular specialist interest in biomaterials and implant technology.

The Biomaterials and Implant Technology Unit operates from purpose built laboratories in close proximity to theatres, core service laboratories and clinical services covering a comprehensive range of specialties which are typically that to be found in a major hospital with acute, tertiary and teaching/research responsibilities. Laboratories include facilities for metallurgical preparation and examination, corrosion testing, materials and equipment testing, tissue assay and SG based computer modelling systems.

Traditionally, the group enjoys a close working relationship with the orthopaedic community in WA with direct responsibility to the Departments of Orthopaedic Surgery and the Division of Elective Orthopaedics in RPH.

The Rehabilitation Technology Unit (RTU) comprises Rehabilitation Engineering, Orthotics and Prosthetic Services operating from U.Block in Shenton Park Campus (SPC) of RPH sited approximately 7 km west of the main campus. RPH (SPC) provides the States only comprehensive and specialised rehabilitation facility with responsibility for spinal injuries, amputee, neurology, neurosurgery and orthopaedic rehabilitation. The Unit provides tertiary services in wheelchair mobility, pressure prevention, specialised seating, complex aids to daily living, augmentative communications (AAC), orthotics and surgical footwear, interim prosthetics and clinical biomechanics to hospital patients and where applicable, to community based patients across the State under the Community Aids and Equipment (CAEP) program.

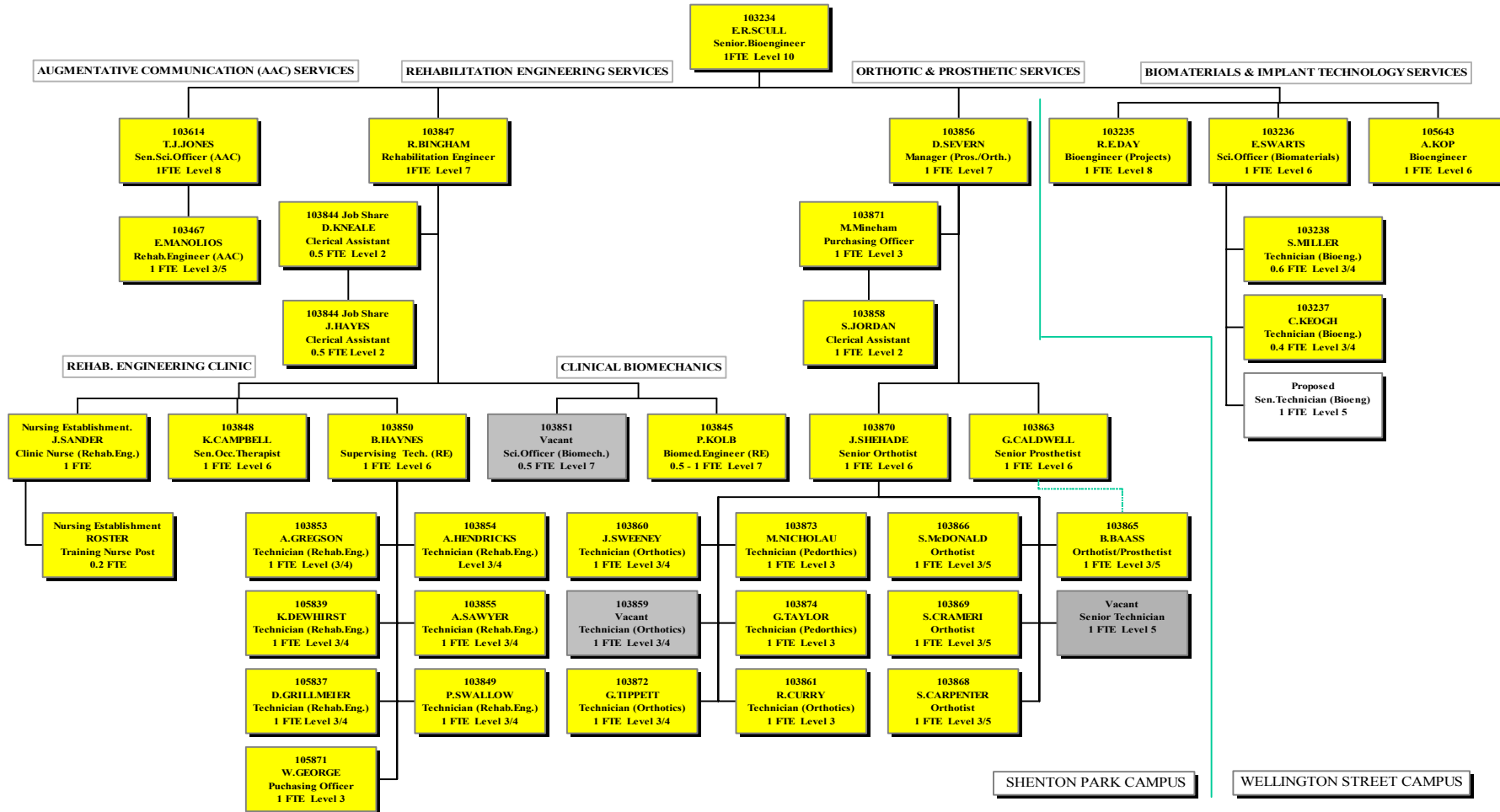
The RTU services comprise 15 professional staff including rehabilitation engineers, scientific officers, nursing, occupational therapy, orthotists and prosthetists, 12 technical and 3 support staff working closely with sessional consultants.

In each of these areas, the Division strives to provide services that reflect world best practice and which maintain a high level of quality and cost effectiveness.



**BIOENGINEERING DIVISION: DEPARTMENT OF MEDICAL PHYSICS, ROYAL PERTH HOSPITAL
REHABILITATION TECHNOLOGY SERVICES (SPC) and BIOMATERIAL & IMPLANT TECHNOLOGY SERVICES (WSC)**

CURRENT ESTABLISHMENT: JUNE 2002



BIOENGINEERING: THE BRIDGE BETWEEN MEDICINE AND ENGINEERING.

Biomedical Engineering has a diverse involvement in medical practice which can be related to the reliance that modern medicine and surgery places on science and technology. An emphasis on technological practice is notable as a hallmark of the contemporary teaching Hospital. In Royal Perth Hospital, Biomedical Engineering is divided into two areas; Clinical Engineering (the responsibility for which is vested in the Technical Service Division of the Department of Medical Physics) and Bioengineering. There is naturally a strong affinity and a close and co-operative working relationship between the two Divisions.

Bioengineering describes the application of engineering science and its resources to the solution of clinical problems. Importantly, the professional engineers and scientists in Bioengineering have training in the biological sciences and a range of experience in clinical practice that facilitates effective communication and co-operation between the engineering and medical professions in addressing these problems. Bioengineering is a clinical support service, applicable to all areas of medical practice and specialisation.

Bioengineering at Royal Perth Hospital has developed from a strong base in mechanical engineering and materials science and in support of kindred areas in orthopaedic surgery and spinal injuries. Current services offered to the Hospital, while not exclusive to these areas, reflect this working relationship in the following areas.

1. **BIOMATERIALS (Routine investigations):** The Division maintains a laboratory facility equipped for a range of material investigations relevant to implants devices and host tissue. A range of investigative methodology is supported, including
 - 1.1. metallurgical analysis and metallographic studies related to material quality (eg. hardness, microhardness, micro-cleanliness and grain size determinations),
 - 1.2. material and tissue testing (eg. employing either of the Instron 10kN servo-hydraulic or 5kN universal testing machines, depending on the load, load repetition and strain rate requirements),
 - 1.3. electrochemical analysis for the investigation of material degradation and corrosion using potentiostatic and galvanostatic methods
 - 1.4. assay of the elements represented in implant materials from materials or contaminated tissue substrates, using AAS and heated graphite furnace techniques,
2. **BIOMATERIALS (Special investigations):** A range of special investigations are conducted by the Division in-house and in co-operation with a number of hospital departments and tertiary facilities at Curtin University and the Chemistry Centre, for example. Such investigations are developed in response to laboratory and clinical needs and typically, include
 - 2.1. routine investigation and reporting of pathology, radiology and microbiology findings associated with implant and biocompatibility responses
 - 2.2. the provision of thin section techniques to prepare cross-sections of implant (metal/polymer) and tissue (bone and fibrous tissue) for histological examination related to host tissue interface and bone ingrowth studies
 - 2.3. ultrastructural and EDAX analysis, carried out in relation to fractography and other investigations. The Division currently uses the Scanning Electron Microscope facility at the Chemistry Centre for routine and special investigations.

2.4. the investigation of factors affecting the performance of ultra high molecular weight polyethylene (UHMW Pe) in the body. The investigations result from the increasing referral of knee arthroplasty in particular, with bearing surface deterioration ranging from minor wear to surface delamination and body fragmentation. A number of methods of spectrometry (IR, Raman and Photo-acoustic spectrometry) have been investigated in co-operation with the Curtin University, School of Chemistry, for the reliable determination of carbonyl and crystallinity indexes associated with oxidation and disruption of the polymer.

Work is continuing to further improve the specificity of investigation techniques and to use them to measure factors related to polymer selection, manufacture and sterilisation that contribute to the premature clinical failure of the implant.

3. **CANDIDATE DEVICE EVALUATION:** The Division has established routines for the comprehensive evaluation of individual devices, implant systems and instrumentation as part of the overall selection process related to use, purchasing and tendering for the purchase of orthopaedic devices in the Hospital.

Evaluation is based on a range of investigations (refer above), carried out in accord with the relevant Australian, ISO and ASTM standards. An appraisal of the design, quality and manufacturing standards of the implant, the implant system and instrumentation is also provided. Information related to the serviceability of devices, the service support provided by the manufacturer and cost is also reviewed. A comprehensive report provides recommendations for consideration by the Orthopaedic Department and the manufacturer and/or supplier, where applicable..

4. **IMPLANT DEVICE TRACKING:** The Division, is working with the Hospital's IT team developing a Theatre Management System for use across the State public sector, to include a module for the effective tracking of implanted devices such as hip and knee arthroplasty, heart valves, etc.. The system is being designed to provide the minimum data required to identify the device, the clinician and the patient and to track it from the point of entry into the Hospital, its allocation to store and/or theatre, its implantation, explantation and disposal. The system is intended to be networked and will be beta tested at RPH prior to consideration for incorporation onto the wider area network with the potential to provide for a State wide tracking system. An initial pilot program will be demonstrated for the purpose of input from all stakeholders prior to finalising file structures, fields and format.

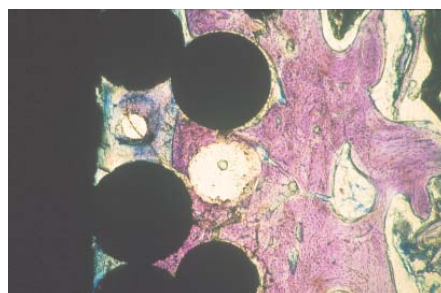
From the Division's point of view it is important that existing and proposed databases in Orthopaedics and Bioengineering (eg. in implant retrieval) are co-ordinated with the device tracking system, to ensure comprehensive and useful data for scientific evaluation. The Division is working closely with IT and Orthopaedics in this regard.

5. **IMPLANT RETRIEVAL AND FAILURE ANALYSIS:** The Biomaterials group provides a comprehensive implant retrieval and analysis service to the Hospital and to other surgeons referring explanted material to the Division. Referral of material to the laboratory is currently at the discretion of the surgeon or the medical staff involved. It is likely that this will become a requirement of the proposed implant tracking system, significantly increasing the surveillance able to be offered by the Division.

Implants, removed due to failure, the need for replacement or as a routine, are referred to the Bioengineering Laboratories, RPH (WSC) for examination.

- 5.1. The implant is removed, handled, cleaned and transported in accord with criteria promulgated by the Biomaterials laboratory. Protocols and referral forms detailing information required by the laboratory, are held in the Theatres of participating Hospitals and are subject to routine review.

- 5.2. Upon receipt the implant is registered, the required information (eg. implant data and medical history) is collected and entered into the laboratory data base. The implant is examined, macro-photographed and a preliminary report is sent to the referring clinician and theatre. Regardless of status (eg. failed, non-failed), all implant components and excised host tissue is stored for future reference.
- 5.3. Where implant failure is profound or where the implant is from a category of devices being investigated by the Service, the device and host (eg. reactive) tissue is scheduled for investigation. The investigation is tailored to the device and the suspected mode of failure and may include;
- *detailed macro and surface investigation of contributory defects or damage.*
 - *fractography using SEM and macroscopic examination.*
 - *investigation of material composition and microstructure, metallographic recording and SEM/EDAX studies,*
 - *material hardness and microhardness determinations,*
 - *determination of micro-cleanliness, grain size and porosity factors in accord with ASTM, ISO and Australian Standards.*
 - *determination of corrosion susceptibility in accord with the mode of failure,*
 - *thin section investigation of the implant - host tissue interface and ingrowth tissue histology,*
 - *examination of host tissue pathology and measurement of trace element loadings in reactive tissue using AAS and graphite furnace techniques,*



- 5.4. All data is entered into the implant retrieval database and a comprehensive report is prepared for the referring surgeon. An opinion as to the factors contributing to failure is offered and a recommendation regarding future practice or need for further investigation is provided where appropriate. It is intended that the implant tracking (and referral) system will improve data collection and convert the record to electronic format. This also raises the opportunity of providing reports to the Theatre system and to individuals over the Hospital internet.

Scrutiny of the database in May 2000 indicated that approximately 3000 explanted devices were registered and held in the implant archive comprising approximately 30% hip arthroplasty, 12% knee arthroplasty, 4% spinal, 45% fracture fixation and 9% other devices. The archive represents an invaluable resource for comparative evaluation and research, which is probably unique.

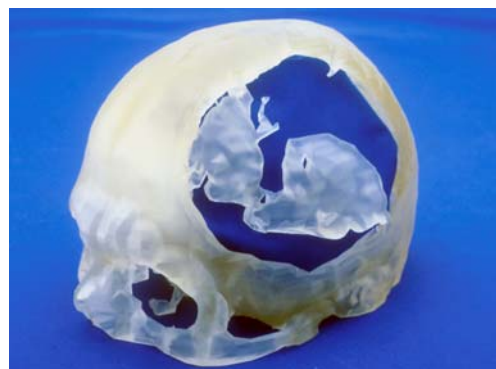
6. **IMPLANT DESIGN & CUSTOM MANUFACTURE:** The majority of implant devices used by the Hospital are drawn from the huge range of devices which are available commercially. The majority of these are imported and are subject to varying registration requirements under the Therapeutic Goods Act.

Where a special implant or procedural requirement is identified, the Division liaises with the relevant clinical staff to identify the problem and to undertake development. This process may include basic research of the problem, experimentation and development of modified procedures, instrumentation, prototypes and custom implant devices for clinical use.

The service combines the expertise of the Bioengineering and Technical Service Divisions with the latter providing manufacturing expertise including advanced CNC machining. Custom projects are contracted with and managed by the Bioengineering Division.

To serve to illustrate the range of projects referred, the Division is currently involved in;

- 6.1. developing a means of reconstituting devices which have been tested (ie. damaged due to handling etc.) in theatre but not implanted. Quality must be returned to accepted ISO and ASTM standards with view to recycling these items to stock.
- 6.2. Implementing a cost effective system for vacuum mixing and the pressure injection of PMMA bone cement. An hybrid system using a combination of reusable and disposable components has been developed to reduce recurrent cost, to improve cement batch quality and to simplify preparation procedures. The system is being implemented after an extensive clinical trial.
- 6.3. Computer assisted design and modelling. Accurate representation of skeletal and soft tissue architecture is an important basis for the custom design of implant devices related to complex fracture fixation, bone stock replacement (eg. using autologous grafting) and arthroplasty
- 6.4. The Division has developed and adapted a suite of software programs which enables data to be read from a range of CT and MRI scanners in the Hospital and around Perth. The image can be manipulated in accord with the work in hand (eg. image edge detection, artifact correction) and software using SG workstation technology enables 3D imaging suited to orthopaedic visualisation and implant design.
- 6.5. Images are downloaded for the production of 3D models using stereolithography (purchased) or CNC machining conducted in house. A routine custom design service is provided in areas including;
 - *The modelling of complex fracture sites for the purpose of surgical planning*
 - *The manufacture of autologous grafts in Theatre to fit large defects (eg.acetabular penetration) and to accept pre-planned fixation devices or revision arthroplasty.*
 - *The manufacture of titanium bone plates for the closure of large skull defects due to trauma or pathology to provide protection of underlying brain tissue and to enhance cosmetic symmetry*
 - *The visualisation of complex spinal architecture*
 - *Evaluation of the method for use in producing facial-maxillar replacement structures and fixation devices*



There is an increasing acceptance of the methodology and recognition of its value in improving the accuracy of surgical outcomes and reducing theatre times related to complex surgical procedures. The technology is in its infancy and there are a number of developments required to further improve its utility and the quality of outcomes including;

- *Design and manufacturing needs to be upgraded to comply with TGA manufacturing standards related to the production of custom devices. The potential for complex designs should be non-destructively "stress tested" using FEA techniques should be evaluated, particularly where custom devices have a load bearing function*
- *Improved methods of design and manufacturing documentation in accord with ISO and/or NATA requirements*
- *Development of an hydrostatic press system (or other appropriate technology) for the routine upsetting and manufacture of titanium skull plates*
- *Development of capacity for the investment casting of small components based on SLA or other CAD produced patterns. Co-operation with the Dental faculty is envisaged.*

- 6.6. The clinical trial of the Beaver hip stem prosthesis for the maintenance of skeletal geometry and localised treatment of infection following removal of a joint arthroplasty. The devices are manufactured by the Division and subject to retrieval and examination on removal. Research into the dosage and distribution of antibiotic delivered from the erythromycin loaded acrylic which comprises the head/neck of the prosthesis is continuing
- 6.7. Investigation of methods for reforming contour plates to be applied to tibial fractures is based on a preliminary estimate of potential cost savings

7. **TRAINING & RESEARCH SUPERVISION:** The Division has a long history of supporting Registrar training and postgraduate research (eg. Orthopaedics, Physiotherapy, Speech Pathology, Engineering and Science). Staff conducts formal teaching in the area of biomechanics, hold Adjunct Research posts and provide a range of teaching/tutorial sessions in the areas of biomechanics, pathomechanics, materials science and implant technology in support of postgraduate programs.

The Division can offer expertise and support services in biomechanics, computing (data collection and analysis), experimental design, prototype design and manufacture, laboratory testing of biomaterials (engineering and biological) and statistics. The Division is networked with kindred laboratories and bioengineers both in Australia and overseas, adding depth and currency to the support offered.

Training and research support activities often develop into more formal and extensive research and development commitments. The Division has working relationships with University Departments in both the Medical and Engineering Faculties and across campuses. In particular, the Division is closely involved with the UWA Department of Orthopaedic Surgery, Curtin School of Physiotherapy, the WA Bone and Cartilage Program (under WA Medical Institute of Medical Research) and the newly formed Motor Skeletal Research Group at UWA Department of Surgery. Direct responsibility for projects has been limited by the normal service demand placed on the services of the Division however the Biomaterials and Implant Technology Group continue to provide co-operative support for a number of projects and research investigations.

REHABILITATION TECHNOLOGY UNIT: PROVIDING QUALITY SERVICES TO DISABLED PEOPLE IN THE HOSPITAL AND THE COMMUNITY OF WA.

The Division provides a comprehensive range of technology services applicable to rehabilitation of the disabled patient, particularly where there is a mixed or multiple injury (eg. spinal injury, orthopaedics) and chronic disability due to trauma or disease (eg. post-polio patients, motor neurone disease, multiple sclerosis, stroke, etc.).

The Rehabilitation Technology Unit (RTU) provides state of the art Orthotic, Prosthetic, Rehabilitation Engineering and Augmentative Communications services. These Services provide approximately 10000 items of patient/client service per annum for a patient population of approximately 15000, as registered and managed on the RTU Clinic Management System. While wheelchairs are provided on permanent loan to patients, the RTU maintains responsibility for a growing fleet of approximately 6000 wheelchairs, with a replacement capital cost of greater than \$14 million.

While service is provided on a State wide basis under public hospital, Community Aids and Equipment Program (CAEP) and private practice arrangements, the capacity to adequately service country and remote areas is restricted by limited resources (incl. Hospital and Regional budgets). The need to provide equitable service to these areas remains a challenge and methods using video conferencing, telehealth and internet based video streaming are being actively investigated and trialed to assess their role in meeting this challenge.

1. **REHABILITATION ENGINEERING:** The Division provides disability technology services in the areas of pressure management, special seating, mobility (wheelchair provision and maintenance), assistive devices for ADL, augmentative communications, etc.. The twelve staff members involved provide patient services and are involved in developments to meet special needs or where there is a general need not covered by commercial options. The Unit, as a result of its specialised service experience, is called on to discharge a State service role.

1.1. **Pressure Management:** Provides a full range of pressure measurement services and specialised cushions for the prevention of decubitus ulcers and secondary tissue trauma with people seated in wheelchairs. Cushioning is based on the RPH contour cushion, with the more expensive options of ROHO, JAY, temper foam, etc. being used as required. Pressure susceptibility due to seating in the wheelchair or due to bed rest is assessed. The major stakeholder group is the SCI patient who are seen as inpatients during their rehabilitation and followed up by routine review. The Clinic Nurse and experienced technical staff provide the service.

1.2. **Wheelchair Mobility - Provision, Service and Maintenance:** The RE Clinic provides both manual and electric wheelchairs on permanent loan to the patient. Temporary loans are also provided while the patient is in Hospital and for the period where the patient's functional status is uncertain. A large percentage of patient's referred to the Clinic have a severe disability which requires a range of technology options to fully support various functional needs. In such cases, the wheelchair will require a unique specification, significant redesign and custom modification. Wheelchairs provided by the RE Clinic are maintained by the Clinic for the life of the wheelchair. Service and maintenance is conducted in-house or may be out-sourced to an accredited service agent. The RE Service has an active evaluation program to ensure that patients are offered a choice of wheelchairs which are competent, safe and reliable and that they are able to be ably supported with service and spares etc. in WA.

- 1.3. Specialised Seating: Specialised seating is often required in the case of severe disability to provide postural support and stability and to improve the functional capability of the individual when using the wheelchair. Trunk support and head positioning and control is an essential element in improving the function of clients with acquired brain injury, cerebral palsy, etc. for example.

Specialised seating often calls for the modification and/or adaptation of the wheelchair and the use of adjunct systems such as trunk supports added to the wheelchair frame or an insert system (eg. foam moulded seat insert, Jay back) and must take into account patient factors such as spinal deformity, muscular instability, spasm responses, etc..

- 1.4. Augmentative Communications: Alternative and Augmentative Communication (AAC) is required for patients with a speech deficit and/or where severe physical disability (eg. tetraplegia, motor neurone disease (MND)) precludes the person from writing, messaging and the use of computer and telephone technology, etc.. Senior scientific and bioengineering staff assist with the assessment of patients requiring augmentative technology such as electronic and computer/software based technologies to provide communication. The AAC team works closely with Speech Pathologists and Occupational Therapists to identify suitable access sites and strategies which will allow the person to use AAC equipment and to provide written communication and/or speech synthesis, etc. for optimal performance. Often the AAC equipment must be integrated with other systems used for mobility (eg. the electric wheelchair) or used in the home, the workplace or for education. Many of the disabling conditions requiring AAC, change (eg. MND, multiple sclerosis) and it is essential that the technology can be upgrade or changed to address the individual's changing needs. The AAC team manages a technology bank which adds flexibility to the service provided in this regard.
- 1.5. Environmental Control Systems: The capacity for a disabled individual to control their immediate environment (eg. airconditioning, radio, audio and television, home security, lights and curtains etc..) can significantly improve their independence and reduce their reliance on support services. The AAC team assists in matching the identified need with the technology options available, ensuring that the specification makes best use of the home environ and other systems used by the client. Often the control of environmental equipment can be integrated with mobility and AAC control systems, reducing the need for and the burden of redundant technology.
- 1.6. Assistive Technology And Custom Equipment: Often there is an advantage provided for the patient by innovative solutions that require an insight to both the disabling condition, the technology options and their unique adaptation to meet special need. The Rehabilitation Engineering team can provide the design and manufacturing expertise to provide such solutions.
- 1.7. Community Aids and Equipment Program (CAEP): The RE Clinic provides its service to clients in the community who are eligible for services under the CAEP, managed by the Disability Services Commission of WA. CAEP encourages the delivery of services close to the client's domicile. Where the equipment required is complex or where the local provider does not have the expertise to undertake the work, the client can be referred to the RE Clinic under the CAEP J schedule, for assessment and provision of their equipment.
- 1.8. Mobile Services: The RE Clinic is in the process of developing a capacity to provide outreach services in to the community and to establish satellite service Units in regional centres. Specialised vehicles have been leased to enable the provision of limited workshop resources on site and to transport wheelchairs for the purpose of trial, assessment and temporary loan etc..

2. **ORTHOTIC SERVICES:** The Division is responsible for State Orthotic Services to adult clients, operating out of U.Block at RPRH, Shenton Park. Fifteen staff, including professional Orthotists and Technicians, provide the full range of orthotic services and modalities (eg. surgical footwear, spinal bracing, load bearing and functional bracing, etc..) required by medical disciplines including Orthopaedics, Neurology, Neurosurgery, Geriatrics etc.. Orthopaedic staff have sessional appointments to the Unit.

The Orthotics Service provides orthotic management in accord with medical prescription. Services include patient assessment, measurement and specification of the orthosis, manufacture, fitting and evaluation to ensure that the equipment outcome conforms with prescriptive and functional requirements.

Professional services are provided in the areas of;

- 2.1. contemporary orthotic practice such as AFO's, KAFO's, TIRR's and conventional bracing techniques. The Orthotic Service, while located at RPH (SPC), provides a wide range of general orthotic services to patients at RPH (WSC) and to public and private patients in other Hospitals and Nursing Homes in the region. The attending Orthotist will service referrals from the Wards and outpatient Clinics across all the motor skeletal specialties.
- 2.2. specialised functional bracing for the upper and lower limb (eg. reciprocating gait orthoses, functional hand splints). The Service can provide both off the shelf equipment and can manufacture custom devices in accord with prescriptive requirements. Being located in a specialised adult rehabilitation facility, the Service is responsible for orthotic services required on the Wards for post surgical and medical treatment and patient rehabilitation. Ward and outpatient services relate to all motor-skeletal conditions but with emphasis on SCI, orthopaedic, neurology and neurosurgical cases, rheumatology and post polio management.
- 2.3. cervical collars and corsetry for trauma management and assistive support of the back and neck
- 2.4. specialised spinal braces for the corrective management of scoliosis and spinal trauma (eg. cervical halos). The Orthotic Service provides a routine professional service to the Scoliosis Clinics and is directly involved in the orthotic management of the scoliosis patient for curve maintenance and correction and for post-surgical support and bracing. The full range of Boston, Wilmington and custom braces are used.
- 2.5. modified orthopaedic footwear, customised surgical footwear and orthotic inserts for the management of pain and deformity. The Pedorthic group conduct specialised clinics in co-operation with both medical and podiatry staff. Treatment is provided in-house or by the specification and delivery of equipment manufactured by approved vendors
- 2.6. the custom design and manufacture of orthotic devices for special functional outcomes and accessory devices used with rehabilitation engineering and AAC equipment. The Orthotic Service is co-located with the Rehabilitation Engineering Service, providing the real advantage of a team approach to complex equipment solutions requiring orthotic input in order to attain optimum function and safety, etc..
- 2.7. Community based services. The Orthotic Service is available to clients in the community who are eligible for services under the CAEP, managed by the Disability Services Commission of WA. CAEP encourages the delivery of services close to the client's domicile. Where the equipment required is complex or where the local provider does not have the expertise to undertake the work, the client can be referred to the RE Clinic under the CAEP J schedule, for assessment and provision of their equipment.

The Orthotic Service provides both experienced staff and in particular, new graduates, the opportunity to gain experience across a wide range of disabilities, requiring a wide range of orthotic solutions. Flexibility to work in each of the specialised areas is encouraged and good working relationships with associated services (eg. Princess Margaret Hospital for Children) enables the inclusion of paediatric experience in the work profile.

3. **PROSTHETIC SERVICES:** The Division provides acute and interim prosthetic management for amputees under the care of the RPH Amputee Rehabilitation Service, located at Shenton Park. The Service employs approximately 1.5 Prosthetists, working to the direction of the Senior Prosthetist and draws on the technical and administrative support of the combined O&P Service. The client mix is primarily composed of new adult lower limb amputees who have had their amputation at Royal Perth Hospital. Amputees from country areas, some other metropolitan hospitals and most new Western Australian upper limb amputees are also treated by the Prosthetic Service.

In 2000-01, the service provided 100 items of patient service, including the provision of 70 interim devices.

- 3.1. Amputee Rehabilitation: The Prosthetist is an integral part of the Amputee Rehabilitation Team and during the rehabilitation process, works closely with the medical, allied health and nursing members of this Team. Accordingly, the prosthetist is involved in clinical decision making involving the patient, to determine treatment and to vary case management based on routine review of the patient's progress.

Services provided by the prosthetist include oedema management using rigid removable dressings and advising the amputee and prescriber of the amputee's prosthetic options. Patient assessment and casting, cast modification, prosthesis fabrication and assembly, fitting, dynamic alignment, monitoring and adjusting prosthetic fit as well as limited amounts of initial gait training are also provided by prosthetic staff. The prosthetist is responsible for the patient's transition from an interim prosthesis to a definitive device.

Prosthetic provision is managed under funding provided through the WA Limb Service for Amputees.

In keeping with a commitment to complete managed care of the patient, assessment and protection of the amputee's remaining foot is a Service priority.

- 3.2. Acute Management:

Rigid removable dressings are routinely fitted to new trans-tibial amputees as part of an oedema management program. The Prosthetist monitors fit and replaces rigid removable dressings as required. This service extends to other hospital sites.

Oedema management is a necessary prerequisite for the fitting of an interim prosthesis.

- 3.3. Provision of Interim Prostheses:

A range of thermo-plastic and laminated endoskeletal prostheses are fitted to new amputees. The amputee's prosthesis is adjusted as their stump volume and walking patterns change and is maintained for the duration of their rehabilitation until they are ready for a definitive prosthesis. The object over this period is to achieve an optimum and safe outcome for the patient. Importance is placed on the management of recycled stock to ensure prompt and cost efficient service provision.

A clinical biomechanics laboratory, located in the same building as Orthotics and Prosthetics, is available to diagnose and fine tune amputee gait if required. The laboratory currently has a priority on determining methods for measuring the outcomes of prosthetic intervention as part of the QA program for the Hospital

4. **CLINICAL BIOMECHANICS:** The Division operates a Biomechanics Laboratory in U.Block at RPRH, Shenton Park. The laboratory is serviced by 1 FTE, currently employing a Scientific Officer and a Biomedical Engineer (Electronics) on a 0.5 FTE basis. The scope of the laboratory has been limited by capital funding but provides facilities for;

- 4.1. Ground Reaction Force Studies Associated With Gait. The laboratory has two Kistler Load Platforms and software capability providing detailed analysis of vertical, A/P and lateral components of ground reaction force, the position of force and moments about the vertical axis. The platforms can be located in a range of positions relative to each other to accommodate different measurement requirements and patient conditions (eg. adult vs paediatric, etc.)

- 4.2. Video Recording. SVHS cameras provide high quality, high shutter speed colour records of gait and other movement patterns. Slow speed and stop frame review of recorded data is available. Image analysis, while not automated, is available for quantitative determination of movement parameters.
- 4.3. Load Vector Studies. A real time image of the ground reaction force load vector can be superimposed on the video image of a patient walking on the load platform and recorded for review and analysis. The method provides an accurate tool for investigation of load alignment from the centre of pressure under the foot and with respect to joints during movement and load bearing. Lateral and A/P (P/A) views are available. The method is particularly applicable to monitoring the efficacy of treatment such as surgical, orthotic and therapy modalities.
- 4.4. Sway Analysis. Quantitative analysis of sway associated with postural stability is available using statistical and frequency (ie. per fourier analysis) determinants.
- 4.5. Foot Pressure Measurement. The laboratory has recently commissioned an instrument for monitoring (and measuring) the variation of interface pressure under the foot during load bearing (incl. walking). Currently the instrument provides a video image of the pressure pattern which can be analysed to provide a qualitative map of pressure zones under the foot which may be affected by gait patterns and pathology, etc.. Work is current to upgrade instrumentation to provide sequential analysis of the gait cycle to more adequately demonstrate the load bearing dynamics of the foot during walking and other movements.
- 4.6. Temporal-Spatial Measurement of Gait. The Division has developed and installed an instrument which provides temporal and spatial (A/P) data including step and stride length, cadence and the timing of swing and stance phases for both feet during gait. The instrument uses opto-electronic sensing which does not require attachment to or interaction with the patient.
- 4.7. Functional Electrical Stimulation (FES). The Division has conducted research funded by MEDWA, investigating the efficacy of FES as primary treatment and adjunct therapy to strengthen muscle and improve the performance of spinal injured subjects using cycling exercise. Currently, a laboratory based stimulator is being developed to improve transcutaneous stimulation with view to assessing the possibility of implementing an affordable home exercise system for SCI patients. The maintenance of clinical services has been limited by available staff resources at this time.

The Clinical Biomechanics group is conducting normal studies to create base line information against which to compare pathological data. The studies are also designed to evaluate the data derived from the laboratory against other workers in the field (eg. Waterloo University). The group encourages referrals in orthopaedics and other clinical specialties and is keen to support research and other investigative programs including instrument system development. The laboratory, working in a clinical environment, is particularly suited to monitoring the effective fitting and adjustment of amputee prostheses but is not currently utilised in this regard.