Winston Churchill Fellowship Report 2002

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Investigating the Current Trends and Advancements in Orthotic management of Paediatric Cerebral Palsy

Report By - Ben McMurtrie – 2002 Churchill Fellow

Period of travel 10-2-02 to 16-5-02

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Introduction

My Winston Churchill Fellowship's primary objective was to travel to Northern America and investigate the latest clinical and technical advances in orthotic treatment for paediatric cerebral palsy. Orthotists, as part of the allied health treatment team, play an integral role in providing orthopaedic appliances for disabled children. These appliances enhance each child's quality of life and optimise their functional abilities. After only a short time in Northern America I discovered that this Fellowship would not be limited exclusively to cerebral palsy. I soon found many areas of clinical and technical interest that broadened the scope of my original topic.

The Winston Churchill Fellowship was a tremendous experience. I visited many facilities and spent time with quite a number of leading orthotists; each of them were considered experts in their respective areas. The Fellowship provided me with a medium which allowed me to interact with a variety of medical and allied health clinicians, and have to contact with the types of patients they treat.

I have documented each area of interest by topic and have summarised my findings and observations, recording current trends, ideas and techniques employed. The views and ideas I present are based on my observations taken from the various facilities visited. Information was gathered from discussion with the various health professionals involved in the treatment processes. I also gathered written information in the form of department protocols, articles written by the staff or journal articles and text book notes from the hospital or department libraries. This report is not a scientific paper and does not necessarily reflect the practices employed by the Orthotic profession as a whole but reflects the current clinical and technical practices employed by the facilities I visited. Each facility had its own specialties and employed practices which were either historically based on current clinical studies, or on information available. They are all regarded as leaders in their areas of work and are therefore the professionals I would be referring to for current orthotic clinical practices.

I would like to thank the Winston Churchill Foundation for giving me the opportunity to travel and investigate an area of particular interest to me that is a dynamic, challenging, intensive and continually evolving area of disability management.

For sponsoring my Fellowship I sincerely thank The Jack Brockhoff Foundation. The foundation's purpose is to provide financial assistance to agencies to enhance the quality of support services to the disabled, the aged, severely disadvantaged families, people with continuing health problems and the homeless. (Australian Directory of Philanthropy).

The orthotists at Geelong Orthotics in conjunction with other specialists and health care professionals from Barwon Health – Geelong Hospital are an integral part of the management team for the paediatric population affected by cerebral palsy and other disabilities. We are the primary providers of orthotic care for the paediatric population in Geelong and the surrounding regions. I will be encouraging the prospect of implementing some of the new techniques learned.

Executive Summary

Investigating the current Trends and Advancements in Orthotic Management of Paediatric Cerebral Palsy

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Fellowship Objectives and key areas of investigation were

- Clinical practices
  - Assessment techniques
  - Measurement and casting techniques
  - Prescription principles of new techniques
  - New theories and techniques behind new treatment regimes
  - Conjunctive "team approach" treatments with other health professionals
- Technical practices
  - Manufacturing techniques
  - New material and component technologies
- Professional education
  - Attended Association of Children's Prosthetic-Orthotic Clinics (ACPOC) Annual Meeting
  - Workshop on Dynamic Ankle Foot Orthosis system

Many of the facilities I visited had several other clinical practices that I gained experience in beyond the initial definition of my Fellowship topic. The selection of facilities/clinics I visited were either primary referral centres known for their expertise in orthotic techniques or they were considered leaders in innovative practices. Staff in these facilities are highly regarded in their respective fields of expertise. Many had contributed articles in medical journals, had been or are currently involved in the collection of data for the basis of investigation into the efficacy of certain practices (new or current), or were actively involved in lecturing, teaching or giving professional workshops.

In summary areas where experience was gained were:

- Use of new techniques and prescription options for lower limb Ankle Foot Orthoses for cerebral palsy and other disabilities
- Management, protocols and techniques in Serial Casting for spasticity
- Infantile Plagiocephaly and Helmet therapy to achieve cranial symmetry
- Current concepts in managing and bracing adolescent Idiopathic Scoliosis
- Taping/orthotic techniques for Congenital Talipes Equino Varus (CTEV- Clubfoot)
- Exposure to motion/gait analysis laboratory practices
- Exposure to research facilities for prosthetics and orthotics
- Techniques in assessment, measuring and impression taking

Dissemination of material
I will be lecturing to various special interest groups and our profession, and currently have eleven lectures booked. I will also be active in investigating each topic further with the prospect of implementing these practises into our clinic and making recommendations for our profession to adopt these techniques. I have also spoken to the staff at The Scottish Rite Children's Hospital in Texas and to the final year orthotic students at the George Brown College in Toronto on the Australian Orthotic & Prosthetic system and my fellowship.

The practices I now have knowledge of will directly benefit the patients we treat for these challenging and complex conditions. Cerebral palsy is a dynamic and continually changing condition that requires regular, intensive and co-ordinated treatment plans. The management of the undesirable characteristics of the disability are optimised when all persons involved in treating are working as a team. Orthotists play an important role in influencing and maintaining optimal musculo-skeletal mechanics. New techniques or advances in current orthotic practices that enhance as well as assist in the treatment and management of such disabilities will always be welcomed.

Itinerary

As I travelled, my Fellowship evolved and expanded beyond the scope of the original proposed itinerary. During my travels the people I met with often suggested I visit a near by clinic or manufacturing facility/company. I received an open reception from these people even on such short notice. This process expanded my itinerary to include 7 extra Clinical - patient care facilities and 3 technical - manufacturing facilities. A total of 23 locations were visited. The locations included clinical facilities/departments, manufacturers, workshops and professional meetings. (Appendix A)

Background

The professional fields of orthotics and prosthetics are relatively young and are continuing to evolve in both the clinical and technical practises. The practices and techniques employed for assessing and fitting orthoses can vary substantially throughout our profession. Variations in designs and materials occur between individuals, local clinics and across countries. The training of orthotists includes the teaching of fundamental principles that are applied in the formulation and prescription of orthoses. These principles form the solid foundation for orthotists to supply an orthosis that meets the needs of the patient. With the use of these principles variations in design may differ amongst individuals but meet the functional requirements and goals equally as well. The old adage of "there is more than one way to skin a cat" applies here. My Fellowship enabled me to observe many new treatment approaches to congenital or biomechanical pathologies. One common thread I found was that we all refer back to our fundamental teachings and principles.

Currently there are no accepted protocols developed that the profession adopts, within countries or internationally, as a whole body. The standardisation of practices and development of protocols or clinical pathways is occurring in certain areas of treatment. Cerebral palsy and scoliosis are two examples. It is apparent that the medical profession is encouraging the movement toward evidence based medicine. This is a process of testing and documenting the efficacy of practices we employ and questioning the possibility of improving these practices. As this becomes more a requirement of current work practises, professionals in the areas of research and development will be crucial in providing some of these answers. The collection and analysis of temporal and spatial data from motion analysis laboratories is crucial for providing these recommendations. Many of the larger facilities had their own motion analysis laboratories or clinicians involved in collecting subjective and objective data or questioning a hypothesis. This often led to the development and improvement of clinical standards or protocols. Clinical trials are also being conducted by individuals or departments.

The role of the orthotist

The orthotist is a trained allied health professional who, following clinical assessment, provides an external piece of equipment (orthosis) to assist in one or a combination of the following

- Optimise or normalize walking patterns
- Prevent further deformity
- Correct flexible deformity
- Increase or enhance balance, increase base of support
- Reduce energy expenditure
- Fix, block range of motion or assist movement across joints
- Assist with postural positioning

To provide the most appropriate orthoses' for the patient's individual need, the orthotist utilises specialised training in both clinical and technical areas. Clinical aspects include assessment and evaluation of biomechanics, muscle strength, joint ranges of motion and characteristics of the neuro-muscular system. Following evaluation and often consultation with other health professionals, parents and the patient, an orthotic prescription is formulated. Orthotists may employ the assistance of a trained technician for the manufacturing processes. The fundamentals of manufacture include modification of the positive moulds or interpretation of measurements taken, componentry selection, materials selection and individual assembly and configuration of the final orthosis.

A sound knowledge and understanding of anatomy, physiology, biomechanics of the body including normal ranges in standing and walking are fundamental requirements before applying this process to assist with various disabling pathologies that are presented to us on a regular basis.

Orthoses can be utilised in many situations. Mostly they are used for every day wear to enhance or optimise the performance of the musculo-skeletal system. Orthoses can also be utilised for:

- Post-operative rehabilitation,
- An adjunct to assisting stretching programs, day or night use

Often the most common goal is to control the position and actions of the lower limbs. To control the limb effectively, the orthosis must be strong enough to resist these strong overactive (spastic) limbs. With control and a strong orthoses comes a physiological trade off. Immobilising a limb across one or more joints can have adverse effects on the muscular system. Immobilising a limb for extended periods of time can lead to atrophy and resultant loss of strength in the muscles crossing the immobilised joint.

This presents a challenge for the orthotist to manufacture an orthosis that will achieve adequate control while having minimal negative effects associated with immobilisation. This is not often easily achieved and benefits or disadvantages may need to be considered. My investigations found that several techniques in orthosis prescription and combined treatment plans assist in addressing these issues. These include:

- Utilisation of lighter plastics for a more flexible orthosis
- Conjunctive use of specific – night splint orthoses
- Serial casting techniques
- Physiotherapy techniques
    - Strengthening target muscle groups
    - Stretching target muscle groups
    - Electrical stimulation
    - Specific gait training

Orthoses for the lower limb

In the growth and development of the orthotic profession there have been many advances and developments in orthotic design and materials. The last 20-30 years have brought many advances that have given the orthotist new prescription options. One of the biggest changes was the introduction of heat formable plastics. More recent advances include the use of "space" materials, carbon fibre and Kevlar and computer aided design and computer aided manufacture (CAD-CAM).

Orthotists today have a vast array of appliances and techniques available for treating limbs affected by cerebral palsy. Using prescription principles, design concepts and materials/components available the orthotist is able to design an infinite number of custom made orthoses, each suited individually to the patient. There are many traditional designs and styles of orthoses for the lower limb still being used that are effective in achieving the goals set by the orthotist. Traditional designs include:

- UCBL (University of California Biomechanics Laboratory) foot orthoses
- Plantar control Foot orthoses – various forms/designs
- Shoe modifications ie wedges, lifts
- Posterior leaf spring AFO's
- Anterior trim – rigid ankle AFO's
- Ground or Floor reaction AFO's, designed to influence knee mechanics
- Hinged, articulated AFO's
    - Incorporating stops at a set range of motion
    - Provide a dynamic assist force to the weaker muscle group

A new generation of concepts

When visiting the clinics I found many innovative orthotists and therapists who are utilising new techniques for disability management and the provision of orthoses. Some of these orthoses have become available from commercial central fabrication facilities. These concepts and orthoses have more recently become a more assessable option for the orthotist to utilise. They include:

- New Generation Ankle Foot Orthoses - NGAFO's
    - Total contact concepts
    - Circumferential designs
    - Tone reducing modifications
    - Development of new designs
- Serial casting techniques
- Techniques in Casting for impressions
    - Fibreglass
    - Multi step casting techniques
- Use of check sockets
- Manufacturing techniques

  - Lamination of orthoses
  - Use of carbon fibre in place of traditional metal components

Exposure to new areas of interest and Revision of current techniques

Although my topic was focused on the current trends for treating paediatric cerebral palsy I found and gathered information on other treatment programs. I was exposed to several new techniques. I also had the opportunity to compare and revise our current practices. Topics and techniques that are not new to our profession are also evolving and being refined by the researchers and innovators in our field.

New areas of interest included:

- Serial casting – CP, spasticity management
- Cranial moulding helmets for Plagiocephaly, asymmetrical head shapes
- French taping and bracing techniques for Congenital Talipes Equino Varus (CTEV) infants

While visiting the various treatment centres I was exposed to the current philosophies and treatment protocols of areas of treatment I had not been clinically exposed to since graduating in 1989. Revision of these areas of treatment included:

- Scoliosis
- Gait Analysis techniques

Other benefits and opportunities gained from my Winston Churchill Fellowship included:

- Ongoing channels of communication with colleagues, individuals with particular areas of expertise
- Development and continuing sharing of clinical/technical information with colleagues
- Possibility of exchange programs of clinicians across countries
- Friendships
- Exposure to special interest groups ie Association of Children's Prosthetic & Orthotic Clinics (ACPOC)
- An understanding of the processes involved in becoming a certified Prosthetist or Orthotist in North America
- Exposure to the Prosthetic & Orthotic educational systems
- An insight into the future direction of our profession, ie new systems available for treating paralysis – Stance Phase Control Knee units
- The possibility of arranging international speakers for our association/profession

Cerebral Palsy

Incidence and Aetiology

Cerebral palsy is the most common neuromotor disorder originating in childhood. The incidence of cerebral palsy is approximately 2 to 4 individuals for every 1000 births. Cerebral palsy is caused by an injury to the brain before, during, or shortly after birth. In many cases, no one knows for sure what causes the brain injury or what may have been done to prevent the injury. Several reasons for the cause of cerebral palsy have been suggested. They are:

- Oxygen deficiency prior to, during or after delivery
- Infection
- Trauma to the mother or foetus during pregnancy
- Cerebral haemorrhaging
- Complications from medical conditions born by the mother, ie diabetes, high blood pressure

Presentation

Cerebral palsy is a neurological impairment that presents as a disabling condition in an infinite number of ways, physically as well as cognitively. Children with cerebral palsy don't have damage to the regional muscles or nerves that present with impairment but have damage to the area of the brain that controls and co-ordinates posture and muscle movement. This functionally alters normal patterns of movement that can make simple every day tasks difficult. Each child has specific characteristics and has to be approached and treated on an individual basis. The condition can present itself in a very mild form; a barley noticeable foot drop deficiency to a form can profoundly affects all the limbs, rendering the individual dependant on others for all activities of daily living.

Cerebral palsy can manifest itself as different types and can affect varying regions of the body. The categorising term describes the most obvious or dominant presentation, although individuals will often show varying degrees of more than one type.

Spasticity: The most common presentation. Muscle tone is overactive (hypertonic) and presents as a tight muscle that has difficulty in relaxing and allowing a full range of motion across the joint it crosses. Deep tendon reflexes are heightened and overactive. The disruption of the reciprocal inhibition function is considered to be a causative factor in the hyperreflexia seen in spasticity (1).

Ataxia: Associated with low muscle tone, irregular awkward and shaky muscular movements. The individual has difficulty in co-ordinating smooth voluntary movements and balancing.

Athetoid: Muscle tone is irregular and a mixture of low and high tone causing jerky and sometimes uncontrolled rhythmic patterns of movement. This can involve the whole body and has a high demand on energy levels. This form makes every day tasks difficult.

Hypotonic: Muscles lack tone and strength to perform movement or maintain limbs and joints in neutral positions, demonstrating excessive amounts of joint range of motion – hypermobility.

Regional classification

Cerebral palsy is also described by the regions or areas of the body affected. The degree of disability is dependant on the severity of the brain damage and region of the damage.

Monoplegia: A single limb is affected

Hemiplegia: Affects one half of the body

Diplegia: Both legs or arms are involved. This most commonly presents as two legs being affected.

Quadriplegia: All limbs are involved

The challenge of growth

The dynamic nature of the growing child continually presents new challenges to the medical team that require ongoing review and re formulation of treatments to meet the changing goals.

Children who are faced with this lifelong impairment have to continually adjust to the changes associated with growth and development. Increases in growth and limb length constantly challenge the body's battle against spasticity. Disproportional bone growth, with associated shortening of the muscle bellies and connective tissues, increases the forces placed upon the joints that the muscles are acting across. Muscular forces can be so strong as to cause partial dislocation of joints, commonly seen in the hip joints, or to affect hygiene i.e. in the groin when the legs are constantly scissored across each other. The summation of all of these factors continually presents new challenges for the child who is standing and walking.

A developing child will "out grow" their orthosis regularly. Orthotic prescription is a continual dynamic process that has to regularly address changing requirements and help achieve functional goals. Orthoses have to keep up with the expected developmental changes in height and weight. Changes in the physiological characteristics of the musculo-skeletal system also need to be monitored. Other interventions including surgery or the administration of botulism toxin-A (Botox) can radically change the type of orthoses required. For these reasons regular and ongoing review processes are required to ensure the most effective orthosis is being used at that particular time of the child's life and physical state.

New Generation Ankle Foot Orthoses

Ankle Foot Orthoses (AFO's) have been used in the past by orthotists for various musculo-skeletal and neurological pathologies. New ideas, concepts and designs have emerged over the last 15-20 years that utilise the prescription principles used in traditional AFO's but also incorporate some new features to enhance the treatment of some specific conditions. Examples of these new concept AFO's include the Tone

Reducing Ankle Foot Orthoses (TRAFO) and the Dynamic Ankle Foot Orthoses (DAFO). The TRAFO was developed to inhibit the negative effects tone has on the lower limb. Features of the TRAFO include specific modifications to the foot plate that stimulate some regions and unload pressure from others. The DAFO also incorporates these tone reducing features and is manufactured from a thinner plastic that encompasses the foot by wrapping over the dorsum.

Development and new methods of manufacturing and applying this new style AFO's began in the early 1980's. Two of the innovators of this new concept were a physical therapist, Nancy Hylton, and orthotist Don Buethorn. These beginnings led to the formation of the Cascade DAFO which is a large central fabrication facility in Ferndale, Washington providing DAFO's for Orthotists and Physical Therapists. Orthomerica also provides an AFO system called TC2. To avoid confusion in differentiating between the various commercial and "in-house" AFO's available, I will refer to these types of AFO as New Generation Ankle Foot Orthoses (NGAFO's).

One of the main areas of interest to me was the use of new techniques and philosophies behind the prescription and manufacture of the new concept AFO's. I had the opportunity to investigate two commercial manufacturers of NGAFO's. I was a registrant in a two day clinical workshop (Dynamic Splinting Workshop for Paediatric Practitioners) in Los Angeles presented by Don Buethorn (CPO, Director – Cascade Orthotics, DAFO). I also had the opportunity to visit and be given a tour of the Cascade – DAFO facility in Ferndale, Washington. I also visited Deanna Fish (CPO, M.S, Clinical Educator – Orthomerica), at her home office in Salt Lake City, who tutored me and provided clinical information on the TC2 system. Both of these companies can provide a fabrication service for overseas orthotists with their respective DAFO - TC2 systems. Prior communication to arrange account details and shipping arrangements is recommended before sending a cast impression with the anthropometric order sheet.

Several primary care facilities I visited were also incorporating design elements of the NGAFO's into their treatment procedures. NGAFO's have mostly been utilised in the biomechanical management of cerebral palsy but have also been used on occasions for the hemiplegic adult. The NGAFO's have several design advantages.

Technical and Design Elements

NGAFO's act like an exoskeleton shell that incorporates the following design elements:

- Total contact concepts
- Circumferential volume control
- Use of thinner plastics
- Tone reducing modifications into the plantar footplate

Total contact concepts

Incorporating total contact concepts into the design of orthoses differs from the traditional methods of applying built up relief areas onto the positive mould prior to the moulding of plastic. The total contact method of manufacturing requires minimal modifications to the positive cast. Modifications that are used may include relief areas for extremely prominent anatomy or return curves where the plastic trim lines of the orthosis terminate on the limb. The increase in brace to limb contact surface area means resultant pressures are distributed over a larger surface area which can increase comfort tolerances. Soft foam pads are incorporated inside the orthosis over the bony landmarks and prominences that could become potential pressure areas. These can include the malleoli, posterior calcaneum, navicular and cuneiform bones. Problems encountered with skin problems or pressure areas are minimised in a well fitted orthosis incorporating this technique.

Total contact design requires exact and accurate reproduction of the limb at the stage of impression casting. Precision is crucial to the effectiveness and comfort of the final orthosis. Casting techniques include the traditional plaster of paris wrap or the use of synthetic or fibreglass bandages.

Circumferential designs

Continuing with the total contact concept, NGAFO's physically wrap around the anatomy of the limb forming an exoskeleton shell. The plastic circumferentially encompassing the dorsal foot region is very thin. This allows the plastic to be spread open allowing the foot to enter anteriorly. Traditional plastic AFO designs are limited to the percentage they can wrap around a limb due to the rigid nature of the thicker plastic, rendering the orthosis difficult to donn. For these reasons the more rigid design orthoses can only capture 50-60% of the circumferential anatomy, particularly around the bony foot complex. Dorsal capturing foot shells have several advantages:

- Enhanced dorsal capture increases the control over a tight or spastic limb that plantar flexes, and therefore increases dorsal control of the foot levering out of the orthosis
- An ankle strap is often incorporated across the instep at 45° to the heel to maintain positive heel positioning inside the orthosis
- The cylinder style wrap AFO has its own inherent strength properties. The intimate fitting AFO's rely on the fixed limb volume being encompassed that has an inherent hydrostatic pressure effect.
- Reduces anterior slipping or migration of the foot inside the orthosis

Thinner plastics increasing movement

The circumferential exoskeleton foot shell in the AFO has the ability to maintain the foot in the most desirable, neutral foot-ankle position. The mechanical relationship between the subtalar joint and the mid-tarsal joints are well maintained in the encapsulating foot shell. While relationships in the rear and forefoot are maintained, saggital movements at the talo-crural joint can be restricted within prescribed ranges of motion by the nature of the design proximal to the foot shell.

The ankle joint (Talo-Crural) has an oblique axis and movement occurs concurrently in a tri-plane motion. Plantarflexion in the saggital plane also incorporates lesser degrees of movement of hindfoot inversion in the frontal plane and forefoot adduction in the transverse plane. Dorsiflexion produces hindfoot eversion in the frontal plane and forefoot abduction in the transverse plane. When one or two planes of movement are restricted, movement across the second and third plane are influenced. If movement is restricted or stabilised in one or more planes, the movement in the third plane will be more graded and stable (2). This relationship means the foot can be well controlled across the frontal and transverse planes while still allowing proportionally more freedom in the saggital plane. It has also been suggested that small amounts of inversion/eversion are important posturally, as they improve balancing strategies at the hip, pelvis and trunk (2).

The NGAFO systems are manufactured from thinner polypropylene, co-polymer or polyethylene, rendering them more flexible than the traditional thicker plastic versions. The increased flexibility allows small amounts of movement that has been shown to have other beneficial physiological effects on the neural feedback mechanism of the foot ankle complex. A more stable and consistent proprioreceptive feedback system can provide more helpful and reliable information for balance and postural control (2).

Some designs unlike the more rigid traditional designs allow increased ranges of movement, particularly in the saggital plane of ankle motion. The increased degrees of physiological movement when walking and standing may promote development of muscular strength of the extrinsic proximal leg muscles (3)

Tone reducing features

Tone is a normal characteristic of muscle physiology and defined as *" normal degree of vigour and tension: in muscle, the resistance to passive elongation or stretch"* (Dorlands Medical Dictionary). Tone and reflex activity assist the infant to balance and maintain posture during the developmental process of standing and walking. As the higher learning of movement develops the primitive reflexes diminish. Overactivity of tone and reflexes in the neurologically impaired infant are major challenge for the paediatric therapist.

Tone reducing concepts have evolved from neuro developmental techniques, utilised in inhibitive casts used by physical therapists to reduce excessive amounts of tone or spasticity. The inhibitive casting techniques of the past involved the custom manufacture of a plaster or wooden foot plate that applied the pressures to specific regions of the foot. The modified foot plates were then wrapped into a below knee walking cast. In the development of this technique over the last 10 years commercial fabrication facilities have produced pre fabricated foot plates that incorporate these features to increase efficiency of impression casting. The efficacy of tone reducing theories have been debated and varying opinions are held in regard to their demonstrable effect.

Stimulation of certain regions of the infants plantar surface of the foot causes motor reflex movements. Electromyographic testing has concluded that theses reflexes are mediated through skin receptors. Two reflexes that can be demonstrated are the "toe grasp" by stimulating the ball of the foot and dorsiflexion by stimulating the inferior aspect of the heel/calcaneum. Bobarth states that if the toes of a spastic patient are "strongly dorsiflexed against the resistance and maintained in this position for a few seconds" a decrease in extensor muscle tone will become apparent (4). As the unaffected child matures this sensitivity gradually diminishes as does the reflex (5). Cerebral palsy children maintain the primitive reflex responses for several years. NGAFO's are designed to reduce pressure over these reflexogenous areas that initiate negative effects on the limb.

The concepts behind the tone reducing features in AFO's are achieved by applying areas of superficial contact that either increase or decrease pressure over specific regions on the plantar aspect of the foot. Modifications are incorporated into the foot plates include:

1. Reduce negative, overactive reflex movements, plantar pressure is reduced under the regions of the foot that induce them
   - Metatarsal heads
   - Central Heel

2. The plantar AFO modifications are designed to increase pressure on the natural arches in the foot which adds to decreases in resultant pressure on the reflex trigger zones. Intentional pressure loading areas include:
   - Longitudinal arch
   - Peroneal arch/notch
   - Transverse arch - Metatarsal dome, proximal to the second to fourth metatarsal heads

3. A toe platform/elevation to maintain the 2-5 toes in 10-15° of dorsiflexion
   - A tapered lift, (approximately 5mm, dependant on size of individual) highest under the second toe tapering laterally to neutral under the fifth toe. This lift is designed to:
     - Reduce effects of tone – The extension of the 2-5 toes provided by the toe lift has been reported to have a tone reducing impact on abnormal extensor synergy and posturing throughout the lower limb (2).
     - Reduce toe clawing/grasping
     - Improve rollover at terminal stance

4. To provide optimal and precise mechanical support. The longitudinal and peroneal arch modifications provide firm medial-lateral control around the calcanei and reduce excessive calcaneal inversion/eversion. Increased control to maintain neutral or desirable subtalar joint positioning is achieved.

Development of new designs

There are many variations of NGAFO's. Some of these include:

- The Supramalleolar orthosis (SMO) design – encompasses the malleoli but allows plantar and dorsi flexion range. This design is particularly useful in controlling excess amounts of plano-valgus or varus without restriction of the saggital motions of ankle movement, dorsi and plantar flexion.

- Two piece AFO, incorporating an inner foot shell – SMO, that keys inside a more rigid outer AFO. This enables the SMO insert to be used independently during crawling activities, allowing the foot to plantar flex and avoid toes being dragged on the floor or preventing internal and external rotation forces on the leg that occur when using a fixed AFO. The rigid outer AFO is used over the SMO to control plantar flexion moments and increase the stability on the lower extremity for standing and walking activities.

- The R-Wrap AFO incorporates two very thin plastic shells, one anterior opening and the other posterior opening to clasp together. When fitted together the orthosis provides a total contact environment and has small amounts of flexibility but provides strong positioning control. This is an AFO I was not directly exposed to. I am currently investigating the details of this design via e-mail with contacts made in America.

With careful prescription the orthotist can prescribe a system that incorporates increased control over specific planes of motion and joints while allowing graded amounts of flexibility in others.

Examples of common presentations and clinical applications are:

1. Diagnosis - Hypotonic plano-valgus foot type without plantar flexion spasticity or contracture
   - Px – Supramalleollar orthosis (SMO) with a circumferential wrap, foot shell that completely encompass both malleoli. The posterior/superior trim line of the SMO is cut away above the calcaneum to allow free range of dorsi and plantar flexion

2. Diagnosis – Hypertonic, (moderate) spastic equino-varus foot type
    - Px - AFO with a circumferential foot piece joining to an anterior trim, rigid upper leg section restricting plantar flexion beyond 90° but allowing dorsiflexion beyond this position by incorporating a hinge with a plantar flexion stop or leaving the top calf strap off

3. Diagnosis – Mild anterior leg paresis - foot drop
    - Px - AFO with a circumferential foot piece joining to a slim posterior (semi-flexible) upright that allows an unrestricted degree of dorsiflexion beyond mid-stance but maintains the foot at 90° during swing phase

Serial Casting

Serial casting is a technique of positioning and stretching muscles and soft tissues with the use of immobilising casts. The most common application for cerebral palsy is to combat the negative effects spasticity has on the available range of motion of a joint. Serial casting for cerebral palsy is mostly applied to the lower limb across the ankle joint and foot to reduce tendencies of tone toward strong plantar flexion. Serial casting can also be utilised on the knee and upper limb. When an antagonist muscle group exhibits stronger tonal tendencies than the opposing group an imbalance occurs in relative available range of motion, active and passive. The range of motion or median position between end ranges shifts closer toward the tighter or contracted muscle group. The imbalance may be due to a weakening of the muscle group, ie paralysis or a stronger more overpowering muscle group, i.e. spasticity in cerebral palsy. Growing cerebral palsy children have the additional predicament of bones increasing in length without proportional muscle growth. This results in a joint with reduced excursion or available range of motion tending toward the side with the shorter muscle. If this imbalance is not addressed over an extended period of time, the imbalance may result in a stronger and harder to influence contracture that may only be corrected with surgical procedures.

Surgical techniques can include (tendon lengthening) physical therapy (stretching programs, electrical modalities) or the use of positioning orthoses. Tardieu et al found that to prevent contracture in a spastic soleus muscle, for stretching to have a long term residual effect, it would have to be applied for more than 6 hours daily. This finding showed that even the most intense stretching programs would not be significantly beneficial. (1)

The physiology behind serial casting

The primary aim of serial casting is to regain the potential, available range of motion across a joint by stretching the soft tissues involved. The serial casting treatment produces a longer muscle. Several researchers have shown that additional muscle length can be obtained by applying a gentle prolonged stretch over a sustained period of time. Maximum length is reached by gradually adjusting and increasing the stretch with the application of casts that progressively increase the angle away from the shorter, tight muscle. Previous studies have shown that the immobilised, stretched muscle belly will respond by growing in length. At a microscopic level the muscle belly lengthens by the addition of sarcomeres – the functional contractile units that construct the myofibril. The myofibrils are the slender units that make up the muscle fibres that make up the muscle belly.

A serial casting program involves careful assessment procedures, a co-ordinated group of therapists and support group. For the most effective results all health professionals involved in this process work as a team. Most often the direct team members applying and removing serial casts are the physiotherapist and orthotist. Serial casting begins with careful counselling and discussion with the parents/carers and child. The parents have to understand the mechanism behind successful casting and be able to recognise potential problems that may arise. The most common risk with this procedure is spasm of the muscles inside the cast, often caused from overzealous stretching. Spasm will increase pressures on the leg by the rigid cast and can lead to skin breakdown, swelling of the limb and undue stress to the individual if not removed promptly. For these reasons the therapists have to have a back up system to enable removal of the cast at any stage.

Assessment of the limb is an essential preclude to the application of serial casting. Most often the physiotherapists will assess the available ranges of motion in the limb. There is an accepted methodology in the measuring and recording of data pertaining to the two angles of significant resistance (R values). Such methodology gives insight into the potential amount of range that may be gained. Comparison of these two values provides the insight in to the benefit serial casting may provide.

The R1 value is a measure of the joint angle that is recorded by moving, or “lifting” the proximal section of the segment at a constant velocity. This angle has also been called the “catch point” and has been shown to represent the functional range values the individual will utilise in normal activity.

The R2 value is the end point of passive stretching available. This angle is higher than the R1 angle and is obtained by applying a more gradual stretch over a longer period of time. The R2 value represents the “potential” angle that could be obtained if a stretch was applied over a prolonged period of time

The greater the difference between R1 and R2 values are the more likely serial casting will be effective. The closer the two R values are the less likely serial casting will increase range and therefore may not be considered for serial casting.

The R1 and R2 values are recorded with the knee both flexed and extended (soleal and gastrocnemious muscle groups). The final set angle of the serial cast is determined by the values recorded with the knee extended, which represents the functional limb positioning during standing and walking. It is generally accepted that the serial cast be set in a comfortable stretched position/angle just beyond the R1 value measured with the extended knee. For reasons explained earlier, if the stretched position is too aggressive, muscle spasm and distress are more likely to occur. Muscle lengthening will occur using this gentle approach. The R1 and R2 values will be higher when measured with the knee flexed and added resistance produced by the gastrocnemius muscle is reduced. For ease of application the decided cast angle can be applied with the knee in flexion, in a sitting or prone position.

Before dorsiflexion in the saggital plane is positioned for casting, the foot and ankle should be maintained in the best achievable position in regards to the hind and forefoot. Once the subtalar and midtarsal joints are optimally positioned then the dorsiflexion force can be applied across the talo-crural joint. It is important to also maintain this relationship during the assessment process to obtain R1 and R2 values.

Procedure

Pre-Casting procedural steps included:

- Receipt of a medical practitioners referral, consent
- Thoroughly discuss and outline serial casting procedure with parents or carers
- Ensure parents or carers
    - Are Responsible and Compliant
    - Can understand and follow protocols and procedures, including essential attendance for cast changes
    - Are able to identify potential negative consequences, numbness, swelling, pressure areas, colour changes
    - Will be committed to administer ongoing maintenance therapies/treatment’s - attend important post-casting programs, physiotherapy, stretching and wear positioning orthoses (day and/or night)
- Obtain written consent from parents or guardian/s. Some facilities would not begin casting without consent

Cast Application Techniques

I observed several techniques and different approaches in applying the serial cast. All methods achieved the goal of maintaining a set joint position. Initial soft undercast materials are wrapped and strategically positioned on the leg. Initial preparation materials differed slightly but all were applied to protect the boney prominences from the rigid unforgiving final shell.

Initial preparations were:

1. Application of stockinet sock
2. Positioning of felt or foam over boney prominences – malleoli, heel/achilles tendon, other palpable prominences
3. Final wrapping with a soft cast under wrap ie velband ®

Application of the rigid cast. The two basic variations were:

1. Fibreglass circumferential wrap
2. Rigid back slab that is then wrapped in a finishing synthetic tape

The initial casts are often set in a plantar flexed position and can eventually be dorsi flexed in the final casts. This creates an uneven base of support and can make ambulation difficult. To accommodate these angles and give a stable base of support wedges can be incorporated either into the cast during the final fibreglass application or by adding the wedges to footwear or cast over shoe.

Casts are generally changed on a weekly basis with an incremental gain of dorsiflexion position. The Hamilton Health Services - Chedoke site in Hamilton, Ontario often kept the same cast in situ for two weeks but after the first week cut wedges from the anterior and posterior ankle area to gain extra stretch before re-bandaging. This technique effectively halves the number of new casts required for this program.

The number of casts used depends on the rate of dorsiflexion gains achieved. 5° has been a suggested weekly goal. A foot that can be maintained in 10-20° of dorsi-flexion is the ideal final result but may not be achieved in all individuals (R2 value dependant). There were procedural variations between clinics visited. On average 4-5 casts are applied over a 4-6 week period to achieve the final result. It was suggested to maintain the final cast in the final dorsiflexed position for 1-2 weeks. Casting would cease if gains in position are not significant between casts.

Knee extension orthoses are commonly used as a gait training aid or as a night splint to maintain stretch on the gastrocnemius, calf muscles.

Continuing of maintenance

It is important to retain the increased range of motion gained with follow up therapy and orthoses. Impression casts can be obtained at the final cast change to ensure orthoses are fitted immediately following the casting program. Orthoses are made for daily usage and often for night use. The Hamilton Health Sciences - Chedoke Site in Hamilton, Ontario included a removable Velcro strap system that could be used on the hinged day orthoses to maintain a dorsiflexion stretch at night. Other facilities manufactured AFO’s with more pliable plastics (polyethylene) with foam linings solely for night use.

Physiotherapists provide important follow up programs that include muscle strengthening, stretching and gait training. This type of follow up therapy must also be supported and encouraged by the parents. The effect of the gained range of motion with serial casting will be optimised with good maintenance. Parents are encouraged to continue with self administered programs at home.

Plagiocephaly and Helmet therapy

Plagiocephaly describes an asymmetrical head shape. Plagiocephaly literally means "oblique head" (from Greek: *plagio* = oblique and *cephale* = head). Asymmetry causes the head to present as rhomboidal shape when viewed from the top. Ears and facial features may also be involved. The asymmetry is accompanied by a posterior occipital-parietal flattened area and corresponding bossing of the frontal bone. Asymmetry is not abnormal, it’s the degree of asymmetry that determines the degree of deformity. Depending on the degree of asymmetry, misalignment of the ears and facial features can be observed. Helmet therapy is a recommended treatment in North America when either of these more obvious effects were noticed or other early conservative treatment was not successful.

In 1992 the “Back to sleep program” was initiated in America by the American Academy of Pediatrics to reduce the risk of sudden infant death syndrome (SIDS). The positive effect of this program is that there has been a 40% reduction in sudden infant deaths since 1992. It was noticed there was a dramatic increase in the incidence of positional Plagiocephaly. Since then several papers have established the relationship between sleeping supine and Plagiocephaly. The American Academy of Pediatrics' now recommends frequent re-positioning and rotation of the infants head to reduce the incidence of Plagiocephaly. It is important to note that Plagiocephaly has not been shown to be associated with any long term complications (6). On current evidence the primary role of cranial re-moulding orthoses is for cosmetic purposes.

Plagiocephaly can be described as synestotic, where premature fusion of the sutures occurs or nonsynestotic which is deformational. There are several other variations of cranial asymmetry. The more common forms are:

Brachycephaly: Symmetrical flattening of the left and right occipital/parietal area causing a superiorly elongated deformity.

Scaphocephaly: Elongation of the skull in a longitudinal direction caused by craniosynostosis (premature fusion of one or more of the cranial sutures) surgical options are usually performed by the Craniofacial Team. Helmet therapy is contraindicated pre-operation but can be used following the procedure. Careful evaluation, cat scanning, x-ray or MRI are used in diagnosing this condition

Causes of Positional Plagiocephaly

Plagiocephaly is reported to occur (depending on different sources) in one to three per hundred births. Reasons for this condition are:

- Intrauterine pressures – usually resolves spontaneously with normal neck range of movement. Exacerbated by large or multiple fetuses or prolonged positioning against the pelvic wall
- Pressures exerted during delivery
- Premature birth - A premature infants' skull is softer and more pliable. Prolonged and frequent positioning on one side may lead to asymmetry.
- Postnatal postural pressures – includes prolonged periods of lying supine on flat surfaces, ie beds, floor, car seating
- Torticolis and secondary positional pressures – a unilateral contacted sternocleidomastoid muscle rotates the head forward and to one side. 85% of plagiocephaly individuals are reported to have concurrent torticollis

Treatment of Positional Plagiocephaly

Early conservative treatment techniques are generally utilized in the first four months of age. Treatments can include

- Aggressive re-positioning and monitoring of head posture, ie more side sleeping
- Stretching programs, particularly when torticolois is diagnosed
- Increased amounts of supervised “tummy time”
- Reduced amounts of time lying on hard surfaces, ie floors and strollers
- Re-orientation of cots to encourage head turning away from the flattened side

If these techniques don’t appear to demonstrate significant results then helmet therapy is considered.

Helmet therapy began 25 years ago and has more recently become a more common conservative treatment approach. In America and Canada the practice of fitting custom made helmets to influence the re-positioning of the asymmetrical skull was common. I was exposed to three different facilities which had developed techniques of manufacturing helmets for the correction of Plagiocephaly. They were

- Tower Orthotics, Seattle, Dianne Simmons
- Hospital for Sick Children, Toronto, Arthur Street
- Orthomerica, Salt Lake City, Deanna Fish (central manufacturer of the STARband helmet)

Each facility or central fabrication service had variations in the manufacturing techniques and wearing guidelines. Although materials and construction methods varied, the principles and recommendations or protocols for treatment regimes were similar. Where time frames for treatment are noted I have used averages of the recommendations from the clinics visited.

In America the licence to manufacture helmets for plagiocephaly and related anomalies is controlled by the Food & Drug Association (FDA). The cranial remoulding orthoses have been classified as Class II medical devices, to date the only orthoses with this classification. There are currently 18 licensed facilities in America. Licensed manufacturing facilities provide central fabrication services for qualified and licensed practitioners.

The mechanics behind helmet therapy

The helmets rely on the application of forces over the high areas of bossing and have spaces or voids for the flattened areas to move into. As the brain grows it expands the bones of the head. There have been no indications that the helmets interrupt or have undesirable effects on the normal development of the brain. There were two trains of thought behind achieving symmetrical re-modelling.

1. Manufacturing a slightly oversized helmet for the brain and skull to grow into
2. Manufacturing a helmet that begins re-modelling by immediately applying pressure from the first fitting. As growth progresses modifications by removal of material in high pressure areas are sometimes required.

Both helmet types achieve their goal by allowing an asymmetrical skull to grow into a symmetrical helmet. The application and direction of forces are determined by the orthotist and become the built in features of the helmet at the modification of initial positive “asymmetrical” plaster impression or model.

Casting and impression techniques

The casting process uses a plaster of paris impression technique to capture the exact shape of the infant’s skull. This method produces a positive plaster replica of the infant’s skull and relies on the skills of the orthotist to add and remove material to finish with the desired resultant shape the helmet will replicate.

Orthomerica have laser scanning equipment called the STARscanner (Symmetry Through Active Remoulding) that replaces the traditional method of plaster casting. The STARscanner is available for clinics with larger patient numbers for direct electronic communication with the central fabrication facility. This technology enables the clinician to electronically send the information collected from lasers and cameras to Orthomerica for modification and manufacture of the STARband helmet using CadCam technology. This technique greatly reduces the manufacturing and delivery times. The STARscanner also enables the practitioner and technician to observe changes in head shape over the course of treatment.

Guidelines for Helmet therapy

Generally helmets are used for a period of 3-8 months depending on the age at which the treatment begins and on the severity of the deformity. The pace of re-formation is determined by the commencement of therapy. The most rapid stage of growth occurs in the first six months, therefore the wearing time will be proportionately less if begun earlier. It is reported that 85% of postnatal skull growth occurs in the first twelve months. It is essential that if helmet therapy is recommended the treatment begin as soon as possible. The ideal age to begin therapy has been recommended at between 4-12 months of age, closer to four months is better. Once the infant reaches 12-18 months of age the opportunity to effectively influence the formation of the skull is greatly reduced. Most practitioners would be less inclined to begin therapy once the infant is 12-15 months of age.

Recommendation for usage of helmets

The following is an example of the treatment process.

1. Assessment and casting
2. Initial fitting, not recommended to be beyond two weeks of initial visit, can be a long consultation (1-2 hours) to fine tune the trim lines, fit and outline to parents the correct “precautions, use and care” details of the helmet
3. Review appointments:
    a. First review - 2-3 weeks post fitting
    b. Follow up appointments every month after until treatment is complete.
4. Removal of Helmet - This is usually when the infant begins to outgrow the helmet.

Helmets for cranial synestosis

It is well written that Helmets are not indicated for diagnosed synostosis. Once diagnosed, surgical intervention is the gold standard treatment. The Hospital for Sick Children in Toronto utilised helmets as a part of their post –operative treatment. The helmet cast impression was typically taken 3-4 weeks post operatively. The helmet is bivalved in the coronal plane to apply an anterior-posteriorly directed force. CAT scanning was also utilised to ensure the cranial plate sutures were still open during helmet therapy.

Scoliosis

Scoliosis is a deformity that presents as lateral curvature of the spine. Some of the known causes of scoliosis are related, to musculoskeletal or neurological pathologies, birth defects or trauma. However, it is reported that in 80% of scoliosis cases the aetiology is unknown (7). The most common form of scoliosis is termed Acquired Idiopathic Scoliosis (AIS) and occurs mainly in adolescents. Scoliosis has been documented to occur in 2.5 out of 1000 children and affect females 5.5 times as often as males (8).

I was exposed to the orthotic treatment of scoliosis in several centres I visited. The majority of this was during my 2 week visit to the Texas Scottish Rite Hospital for Children (TSRHC), one of the nation's recognized leaders in the treatment of orthopaedic conditions, related neurological disorders and learning differences. This facility and the medical staff are highly regarded and a leading authority in the treatment of scoliosis. It was visibly evident that the TSRHC was extremely child friendly with colourful themes, playgrounds and a popcorn machine in the foyer. Many families travel large distances from within Texas for treatment. The hospital’s surrounds and the staff make these long days, where the child may be seeing several specialists, as enjoyable as possible.

The prospect of wearing a large brace that encompasses most of your trunk is a challenging concept for a body conscious teenager to accept. The medical staff at the TSRCH are experts in explaining why a brace is required, often, for many years. I soon realised that the counselling element of treatment is considered as one of the most important aspects of the treatment as compliance is required for a successful program. It was carefully and tactfully explained to patients and parents that the purpose of consistent and committed use of a brace for up to 23 hours in the day was to avoid the prospect of future surgery. Otherwise they are faced with the possibility of a progressing spinal curve in the unbraced spine that may eventually require surgical correction.

Bracing for scoliosis is regarded as the most successful conservative treatment for maintaining and preventing lateral curves progressing. Bracing is used as the individual grows through adolescence and toward spinal maturity. There have been many studies and articles demonstrating that bracing does not reduce the angle of curvature but when orthoses are applied correctly and worn regularly they prevent further progression. Curves are more likely to progress in the growing spine if not controlled or maintained in a brace, although there are cases where the curve progression is not halted even with the most efficient braces and compliant patients.

The main goal of bracing is to prevent curves from increasing and to avoid surgical procedures required for large curves. Braces are worn for 16-23 hours a day to prevent the curve from progressing and reaching a Cobb angle of 40-50° where spinal fusion is considered. The Cobb angle measuring technique is accepted universally for evaluating lateral spinal curve angles.

There are the exceptions, but generally spinal curves presenting with a Cobb angle less than 25-30° are not considered for bracing. Bracing is considered when regular monitoring of a curve angle shows progression and begins to measure greater than 25-30°. Bracing is also used if a patient presents for the first visit with an x-ray demonstrating an angle of 30-45°. The rate of curve progression is more likely in greater angle curves. It is generally accepted that spinal curves do not progress in the mature adult spine unless the curve is of significant angle, greater than 30-45°, and has no physiological side effects. It is also accepted that Scoliosis in the adult can contribute to earlier onset of osteoarthritic changes. The potential risks of not treating spinal curves early include the progression of angles, and in the long bone deformation or wedging of the vertebral body at the apex of the curve (7).

There are variations of thoraco-lumbar-sacral orthoses (TLSO) that all have the common goal of applying triangulated forces (3 point pressure system) on the spine. The skill comes in the application and magnitude of forces to achieve correction of the spinal curves. The Boston style jacket is one commercially available orthosis amongst many. TLSO’s are prescribed for curves with apices below the seventh thoracic vertebrae. The Boston jacket can be either custom fitted from a pre-fabricated blank that are ordered after recording a series of anthropometric body measurements. Some clinics prefer to custom manufacture the majority of their body jackets. The TSRHC mostly utilised the pre made Boson brace and are the choice of TSRCH for managing double curves. The Boston blanks are modified with precision or “blue printed” from a 1:1 scale, full spine, A-P x-ray. The transfer of measurements from the x-ray to the jacket ensured trim lines and internal force pads were exactly positioned to provide the three point pressure to correct and control the specific curve/s. Markers are placed under the correction pads to ensure the pad placement is ideal when viewed on an in-brace x-ray. Clinicians aim for 50% spinal correction in TLSO’s to prevent further curve progression. To ensure the spine curve is reduced and corrected, in and out of the brace A-P x-rays are used to compare Cobb angles between the two circumstances.

The Charleston bending brace is another style of TLSO used for single lumbar or thoraco-lumbar curves less than 35°. This orthosis is only used at nights and achieves greater amounts of correction (90-100%) for shorter periods of time. This is an attractive alternative for individuals who are not likely to wear a brace during the day.

It is imperative that regular reviews are conducted to monitor the fit and comfort of the brace in a growing individual and ensure the brace is providing the required correction and control. Scoliosis treatment and final outcomes are maximised by:

- A multidisciplinary team approach
- Optimal biomechanical spinal correction from the brace
    - Precise application of three point pressure
    - Maintenance of firm strap tension
    - Maximised mechanical lever arms, trim lines
- Patient compliance
    - Enhanced by positive support and understanding from family and friends
    - Comfort of the brace (ensures wearing schedules are met)
    - Peer pressure/support
- Solid commitment to the brace wearing schedule - 16-23 hours
- Regular attendance of examination and/or X-ray review appointments, every 4-6 months

Once spinal maturity is reached the brace can be removed. Spinal maturity is assessed and estimated by using the following signs and indications.

- Risser sign - the epiphyseal growth plate fusion on the iliac crest of the pelvis and is nearing full fusion at level 4-5
- The female patient is 18-24 months post-menarcheal
- Closed triradiate cartilage (on x-ray of wrist)
- Velocity of growth has ceased or not evident in two successive review visits.

There is still debate on current practises when bracing scoliosis. The American Academy of Orthotists and Prosthetists have formed an expert panel of clinicians to formulate clinical standards and develop treatment guidelines. The current treatment recommendations come from studies and the consensus of current practises today. There are still many unanswered questions that form the need for ongoing clinical study and trial (7). Some of these questions are:

- The optimal number of hours in a brace required to maximise effect and outcomes
- Amounts and goals of curve correction, and for how long
- Which style of bracing is considered most efficient
- How often should follow up, review appointments be done
- Which indicators are used to estimate skeletal maturity

The TSRCH are currently involved in a clinical study using a sensor that monitors patient compliance and patterns of brace use to determine whether 16 or 23 hours of use should be the recommended dosage of brace wear.

If bracing is not effective in slowing the progression of curves or not indicated for more advanced curves, surgical fusion techniques are used. Fusion techniques use the implantation of instrumentation and bone grafting. Bracing is sometimes utilised to protect the spine post-operatively and assist in the rehabilitation phase.

Oregon Orthotic Systems

Oregon Orthotic Systems (OOS) have a central fabrication facility in Albany, about 2 hours drive South of Portland, Washington. I attended a 3 day workshop conducted by the OOS director, Kyle Scott, in Sydney in September 2001. I was able to arrange a visit to the OOS facility to review their philosophy and observe some of the techniques used in manufacturing their orthoses. Their system utilises the use of fibreglass casting techniques and lamination technology used in prosthetics to manufacture ankle foot orthoses (AFO's) and knee ankle foot orthoses (KAFO's).

Philosophy behind OOS

The assessment and prescription principles behind the Oregon Orthotic System is critical. Once a laminated orthosis has been manufactured it is difficult to make significant alterations to the rigid laminated structure. Particular emphasis is placed on the accurate assessment of the limbs anatomical features, pathomechanical and biomechanical characteristics.

OOS base their philosophy behind currently accepted biomechanical theories that address the correction or maintenance of pathomechanical deformities. Biomechanical correction relies on the successful application of three point pressure systems to control undesirable rotational elements in the three planes of movement (transverse, sagittal and frontal) on the individuals' musculo-skeletal system. OOS use a biomechanical classification system that fundamentally addresses rotational deformities and categorises them into the **IRD** (internal rotational deformity) the **ERD** (external rotational deformity) or **NRD** (non-rotational deformity) headings. These deformities can be summarised.

The **IRD** is described as "A pathomechanical rotary deformity of the lower limb in which the transmalleolar axis rotates internally, secondary to distal joint deviations". Joint deviations include:

- Forefoot abduction
- Midtarsal depression
- Hindfoot valgus
- Internal rotation of : talus, tibia/fibula and femur

These deformities are most often related to ligamentous deformation, musculotendinous imbalances or skeletal deformity. Ie traumatic paralysis, tibialis posterior rupture

The **ERD** is described as "A pathomechanical rotary deformity of the lower limb in which the transmalleolar axis rotates externally, secondary to distal joint deviations". Joint deviations include:

- Forefoot adduction
- Midtarsal elevation
- Hindfoot varus
- External rotation of : talus, tibia/fibula and femur

These deformities are most often related to neurological deficiencies ie, cerebral vascular accident, head injuries, multiple sclerosis or etiological pathologies ie, Poliomyelitis, Spina Bifida

The **NRD** is described as "A pathomechanical deformity of the lower limb in which the primary plane of involvement is either in the saggital or coronal plane"
These deformities can include:

- Genu recurvatum
- Genu valgum/varum
- Midtarsal dorsiflexion secondary to calf contractures
- Pes cavus

Effective orthotic solutions rely on sound assessment and recognition of pathomechanical or biomechanical factors that each individual presents with. Once these factors are recognised orthotic prescription incorporates the use of influential static and dynamic forces to either

- Control or re-position a flexible deformity
- Encourage a more normal gait pattern
- Increase the base of support
- Prevent further deformity, soft tissue or osseous
- Improve efficiency of mobility, ie reduce energy consumption

Progressive reduction of contractures

One of the design goals of orthosis prescription is achieving an "ideal" and appropriately functional skeletal alignment with neutral foot and ankle positioning. The orthotist has to subjectively decide what reasonable degrees of correction are achievable with the application of an orthosis. This may be easily achieved in the flexible foot or impossible in a limb that has an inflexible acquired or anatomical restriction. The orthosis prescription now requires accommodating that positioning by posting techniques. Posting may include a medial wedge to accommodate a forefoot varus or a heel lift to accommodate a dorsi flexion block. Posting enables the best achievable position while providing a stable base of support for standing and walking.

OOS implement that a deformity secondary to a musculo-tendinous or ligamentous contracture can be slowly corrected by placing slow incremental forces on the effected limb over a period of time. The system approach is to progressively stretch the musculotendinous and ligamentous structures. Traditionally an orthotist's view is to capture the most "functional" limb position and manufacture an orthosis that positions a limb in this pre-determined static position. The OOS AFO/KAFO's utilise an adjustable double action ankle joint that can be easily altered through the period of range of motion gains and rehabilitation.

An example of this technique is the plantar flexion contracture that can be a most disruptive deformity for standing and walking. A plantar flexed foot can be initially accommodated by reflecting the corresponding joint position in the orthosis and using a series of heel wedges. The amount of dorsi flexion can be gradually increased in the ankle joint to stretch the posterior soft tissues and muscle groups with concurrent removal of heel wedging to maintain the limb perpendicular to the ground, ensuring a stable base of support. Another example can be to accommodate a deformity such as an acquired forefoot varus, secondary to a plano-valgus foot or IRD. Once the subtalar joint (rearfoot) is corrected extra material in the form of a medial forefoot wedge is initially added into the footplate to accommodate the forefoot varus deformity. As tolerance permits, material is removed slowly and progressively as the forefoot pronates toward the more acceptable, functional and neutral position in relation to the corrected rearfoot.

Accelerated application of this technique to the soft tissues could lead to reactive muscular spasm, tearing or causing reactive scar tissue formation. This technique should not be applied to fixed or osseous deformities that cannot be influenced. The orthotists/therapists judgement and patient feedback are crucial to the success of this technique.

Assessment and Casting

OOS recommend the use of fibreglass for impression taking and utilise the segmental casting technique. Segmental casting allows the orthotist to achieve more effective anatomical correction and positioning of the limb in all planes of movement with reduced effort.

Manufacturing

Laminating an orthosis is not a new technique and was a practise utilised by orthotists prior to the introduction of thermoplastics. Modern laminations techniques are enhanced with advances in resins and reinforcing materials. Lamination techniques form the basis for many prosthetic practises for manufacturing stump sockets for residual limbs and as the outer surface of the exoskeletal prosthesis. Laminating an orthosis has several advantages in comparison to the more common construction using high temperature plastics such as polypropylene or co-polymers. Materials including fibreglass, Dacron and carbon fibre can be incorporated in acrylic resin laminations. The incorporation of carbon fibre into a laminated orthosis increases the inherent strength significantly while reducing the bulk of material required, rendering it thinner and lighter. The weight and function of an orthosis has been shown to directly influence the energy requirements for walking. The lighter orthosis requires less energy expenditure as will an orthosis that can effectively improve the patients gait pattern, even if it is heavier than a lighter less effective orthosis.

Adjustable double action ankle joints laminated into the orthosis allow the orthotist to finely adjust amounts of motion in the saggital plane. The ankle can be either locked in a specific ankle position or allow variable amounts of motion.

Check Sockets

Diagnostic check socket orthoses can be manufactured by OOS prior to issue of the definitive laminated orthosis. SCOPe - Southern California Orthotic & Prosthetics in San Diego also employed this technique. Check socket orthoses enable the orthotist to ensure all of the mechanical requirements are met by the orthosis and pressure distribution will be tolerated by the weight bearing limb. The diagnostic check socket orthosis is manufactured from a transparent PETG plastic that enables easy observation of pressure placement and skin colouration. Further recommendations or alterations can be done to the positive cast before the definitive orthosis is manufactured. Although orthotists have the required theory, training and skills in manufacturing an orthosis, there is an element of subjective judgement used throughout the manufacturing process. It has often been said an artistic element is required in our profession. A diagnostic tool like this reduces ‘guesswork” and ensures that corrective features and comfort of the orthosis are met, particularly when treating a challenging or complex patient.

Follow Up and the Multidisciplinary approach

Progressive review and ongoing adjustments by the orthotist are an essential factor ensuring maximum therapeutic goals are being met by the orthosis. Reviews with the multidisciplinary team who are all working to maximise the patients’ potential are an important factor that will ensure the patient is given the best chance to achieve optimal results. Communication amongst the health professionals involved will be an important factor to ensure individual programs and goals will be progressive and cohesive.

Changes occur to the body following the fitting of an orthosis that alters the previous state of inequity. Factors that may be present are:

- Alteration of joint positions, internal joint surface congruency
- Pressures exerted on the limb, ie skin, boney prominences
- Altered base of support
- Change in limb length with a correction of lower limb deformity (can alter hip or spine mechanics)
- Stretch applied on soft tissues
- Relative shortening of soft tissues on the contralateral side
- Increased walking efficiency or reduced metabolic cost for ambulation

Gait training with physical therapists will be important in the initial adjustment phase following the fitting of an orthosis as well as maximising the patients potential to utilise the features in the orthosis correctly and efficiently. Altering the gait pattern will include recognising and managing undesirable secondary, compensatory movements. Adaptation to the new way of walking will require practise and the re-education of muscle groups, soft tissues and the proprioreceptive elements of the neuromuscular system.

Stance Phase Control Knee Units

Various Knee Ankle Foot Orthoses (KAFO) designs can be used to control deficient quadriceps muscles that cause uncontrolled knee flexion in the saggital plane while standing or walking. One commonly used design incorporates lock/unlock knee joints that are either always locked for standing or walking, or manually unlocked for sitting.

Currently there are some new advances in knee joint designs for use in KAFO's or knee orthoses that enhance the gait pattern. These knee joints are called Stance Phase Control Knee Joints. These joints facilitate an easier, more efficient and smoother gait pattern by maintaining the knee safely in a locked state during stance phase and unlock during swing phase to enable knee flexion and toe clearance. I was exposed to 4 commercially available designs. I have briefly summarised them by Manufacturer, commercial name and provided a very brief description on the mechanism and the relevant web page for more information.

- Otto Bock – Free Walk – Uses a locking mechanism control cable connected to the foot plate, contained in the tubular stainless steel sidebar. The automatic lock is initiated by knee extension prior to initial heel contact, and is only released to swing freely when a knee extension movement and dorsiflexion occur simultaneously in terminal stance.
  www.ottobockus.com/products/op_freewalk.htm

- Horton – Stance Control Knee Joint –The knee mechanism is activated by a push cable connected to the AFO section of the KAFO that locks on initial heel contact. The joint, which has a switch, can be used three ways: 1) free knee, 2) locked in 180-degree extension, and 3) stance control mode.
  www.hortonsoandp.com

- Becker Orthopaedic - Electro Magnetic Stance Control - A gas spring pushes the knee joint into full extension, providing geometric stability of the knee at heel strike and allows passive flexion of the knee during the swing phase of gait. www.beckerortho.com/knee/9001.htm

- Basko – Swing Phase Lock - The lock/unlock sequence is detected by an internal pendulum inside a single lateral joint that reacts to changes of the angle of the hinge in the sagittal plane. A convenient switch that can be changed between three modes – Lock, Unlock, and Swing Phase mode can be attached to the upper thigh shell. www.basko.com

Because there are variations between the manufacturer's knee joints the following indications and contra-indications may not necessarily apply to each.

Indications

The stance control knee joints have been indicated for isolated paresis or partial paresis of the quadriceps muscle due to:

- Poliomyelitis, post-polio
- Multiple Sclerosis or similar diseases
- Unilateral paralysis
- Incomplete spinal cord injury
- Trauma
- Neurological pareses

- Cerebral Vascular Accident (Stroke /Apoplexy)

Contra-Indications

- Knee-Flexion contraction larger than 10º
- Uncorrectable genu varum/valgum >10°
- Central Paresis/Paralyses
- Hip contractions
- Lack of motivation, impaired cognition or wrong expectations

It will only be a short time before this technology will be available in Australia as an option in our current selection of componentry for alternative prescription practises.

Motion Analysis Laboratory and Research Facilities

Each health professional has a system of assessment that is tailored for each patient. Most professionals have standard practices of quantifying or measuring and recording objective and subjective information. These practices and parameters of assessment can differ greatly between professions and groups of like professionals. We also know that there can be differences between inter or intra-tester reliability when reproducing standard anthropometric measurements, ie joint angles. Most clinicians rely on observational skills and knowledge through formal training programs and experience.

Many advances have been made for increasing the accuracy of measuring temporal and spacial aspects of human locomotion. The Motion laboratories measure joint kinematics (motion) and kinetics (forces). These advancements have been made possible with the advent of motion or gait analysis laboratories that are managed by an expert team of physical therapists, biomechanical engineers, bioengineers, researchers, data analysts and doctors. To understand pathological gait patterns of individuals we first have to understand the fundamentals and have guidelines of what are the expected “norms” of walking. Over the years pioneers and researchers such as Inman, Sutherland and Perry have measured and collected data that provides a base line to compare pathological gait against.

Laboratories visited

- San Diego Children’s Hospital - Motion Analysis Lab
- Scottish Rite Hospital for Children, Dallas
- Northwestern University Medical School – Prosthetics Research Laboratory and Rehabilitation Engineering Research Program, Chicago
- Bloorview McMillan Children’s Centre, Rehabilitation Engineering Department, Toronto

Motion laboratories can utilise several methods for measuring and recording the characteristics of human movement. Equipment may include

- High speed video camera systems using multiple cameras at different angles that record spacial positioning of reflective markers attached to anatomical landmarks. Data from the markers is collected and analysed by computers that reconstruct the individuals gait pattern and can be viewed or analysed on a computer screen or spreadsheet format
- Force platforms that measure the three components (directions) of force. This information can be used in conjunction with kinematic data to calculate joint moments
- Foot pressure platforms that analyse plantar pressure variances while standing or walking
- Digital or analogue video systems that record saggital and coronal plane footage
- Digital cameras for space/time records
- Electromyographic systems show when muscles are active or resting. Two systems were observed, the fine wire and surface electrodes
- Portable monitors that measure metabolic gaseous exchange ie oxygen consumption rate (VO_2), carbon dioxide production. The Motion Laboratory at the Scottish Rite Children’s Hospital, Dallas, were measuring the energy expenditure in disabled children.
- Treadmills. The San Diego Children’s Hospital - Motion Analysis Lab have a treadmill with two force platforms fitted underneath the belt. This was used to analyse aspects of walking and running. This equipment was being used analyse biomechanical and energy analysis in athletes

In my travels I visited several motion analysis labs that use “normal” range data collected by previous researchers/facilities and their own. Most facilities were continuing to collect their own data to form their own “baselines” when comparing and analysing pathological gait patterns. This is done to reduce the margins of error when analysing data against “baseline” data from other labs that have different measuring equipment and techniques in collecting and mathematically analysing data.

Motion labs are often involved in research and development studies. Some of the reasons for analysis in the medical arena are:

- Collation and analysis of standards and variances in “normal” human biomechanics
- Collect specific information on disabled individuals for close analysis to base further medical recommendations, i.e. a treatment plan that could include, tailored physiotherapy programs, orthotic prescription or surgical intervention
- Analysis for post-surgical or neurotoxin administration (Botox) to quantify outcomes
- Research studies for testing new hypotheses, analysing old practises that can be a base for new recommendations

The San Diego motion laboratory covered a wide spectrum of topics including:

- sports medicine and analysis
- orthotics, prosthetics, and orthopaedic bracing
- orthopedic surgery techniques
- footwear biomechanics
- muscle physiology
- spinal cord abnormalities
- pharmaceutical interventions

The various Motion analysis facilities were involved in analysing a range of patient pathologies including:

- Cerebral palsy
  - Pre/post surgical analysis
  - Pre/post Botox-A analysis
- Congenital abnormalities
- Major joint injuries
- Neuromuscular disorders
- Peripheral nerve injuries
- Central nervous system tumors (brain and spinal cord)
- Lower extremity limb deficiencies, including amputations

I was able to visit the Northwestern University Prosthetics Research Laboratory and Rehabilitation Engineering Research Program, a facility that researches and develops Prosthetic and Orthotic ideas and components. I met with Stefania Fatone an Australian Ph.D graduate from the National Centre for Prosthetics and Orthotics. Stefania is employed as a Post-Doctoral Fellow and is involved in research, investigating how ankle-foot alignment and foot plate length of AFOs affects gait in patients with hemiplegia following a Cerebral Vascular Accident. Stefania is one of the few Prosthetists/Orthotists involved in this important field of investigation for the benefit of our profession.

There is a growing need for scientific studies quantifying and recommending the efficacy of accepted treatments of the past and present. Many claims of efficacy, using specific treatments/orthoses, are unsubstantiated and are based on anecdotal, historical or subjective experience. Continuing research and development conducted by individuals, facilities and motion analysis laboratories are crucial for the continuing development of the sound and proven treatment programs we employ. The investigative people are who we look to for testing current techniques, recommending new treatments and developing new orthoses for future application.

Technical Aspects

Several technical techniques and manufacturing processes were observed and are described briefly in the previous sections of this report. The following techniques were the most interesting areas of the technical aspects during my Fellowship.

Casting techniques

In order to produce a custom made orthosis an impression mould (cast) must be taken. This cast is called the negative. This process becomes the foundation for a successful orthosis. Following patient assessment, the orthotist decides what will be the most functional or corrective position the orthosis will be required to achieve the goals and needs of the individual. This is where the orthotist has to utilise all their judgement skills and expertise.

I found several variations and new ideas for taking negative cast impressions. The most striking difference was the amount of practitioners who use the synthetic or fibreglass casting tapes. This technique has several advantages:

- It is a clean process compared to using plaster of paris
- An easy material to use at satellite locations or at the bed side in hospitals
- Easy to make corrections for optimal positioning before pouring liquid plaster for the production of a positive cast
- Strong yet flexible that is not easily damaged in transportation
- Ability to mould the limb easily in steps

The use of two or more steps in the casting process is often utilised. It can be very difficult to achieve the optimal positioning the foot/ankle and sometimes knee all at the same time with one pair of hands. Using a two or three step process enables the orthotist to be more positive and accurate when attempting to position two or three planes of anatomical correction. Casting can be a difficult process particularly if an infant does not understand the process and struggles with the orthotist. Often a wriggling and very strong infant can destroy a traditional plaster of paris cast within seconds. The flexibility of fibreglass allows easy re-construction of the shape required if deformed during the casting process. Fine tuning or further cast corrections can also be easily achieved by wedging and stapling the negative mould at the required angles before filling with plaster.

Example - casting the lower limb using a three step technique for a contracted Equino-Varus foot/ankle.

The three step process means we can wrap segments of anatomy separately to obtain optimal positioning.

1. In this case the foot is wrapped from below the ankle to over the toes. This allows the orthotist to obtain optimal positioning and correction of the midfoot in relation to the rear foot and the subtalar joint positioning in all three (coronal, transverse, saggital) planes. Metatarsal abduction or adduction can also be corrected at this step.
2. The second step involves wrapping the lower limb from below knee to above ankle.
3. The final step involves tying the two segment casts together. This step involves the positioning of the talo-crural joint in the saggital, coronal and transverse planes. Often correcting the foot in a dorsiflexion direction to plantigrade, against strong or tight post-tibial muscles is difficult. Moving and maintaining the foot in this position is much easier when manipulating the foot encompassed in the rigid tape without being concerned about losing the initial corrections already obtained in the first step.

Casting with pre-fabricated foot plates

Both Cascade-DAFO and Orthomerica had their own footplate designs available for the orthotist to impression cast the lower limb for an AFO. The footplates are a pre made, rigid thermoplastic plantar foot shell that are available in all sizes and two widths. The footplates incorporate pre-positioned tone reducing modifications. The footplates may fit the individual immediately without further need for custom adjusting; otherwise they can be modified to suit individual anomalies. Customising the footplate involves the process of adding plaster strips to build up the areas of the forefoot plate, longitudinal arch, transverse arch, peroneal arch and heel cup. An example of this would be to accommodate forefoot varus/valgus anomaly by adding a wedge or post under the forefoot.

Orthotists are trained to take hand moulds/casts. I was initially reluctant to accept that a foot plate is really required. After using the footplates I can identify the advantages, but feel the competent caster can manage without them. I have listed my perceived advantages and disadvantages of the footplate system.

Advantages

- Plantar mechanics and characteristics of the foot can be accurately positioned and maintained during further steps of casting. This may require additional modifications to the supplied footplate.
- Dorsiflexion or midfoot break across the mid tarsal joints is reduced when dorsi-flexing the ankle by applying an upward force on the plantar surface of the foot, toward the ideal position

- Forefoot soft tissue spreading and deformation is reduced when loading the plantar aspect of the forefoot when obtaining the talo-crural optimal position
- Reduces the time required when modifying the positive cast as all plantar corrective features will be reflected into the positive mould

Disadvantages

- More time consuming process, particularly when treating children with behavioural problems or short attention spans
- Initial expense when purchasing full sets of left and right in the wide and standard options
- Inexperience casting persons or a determined and strong child can lead to slippage of the foot plate in the final wrapping stage

Prosthetic and Orthotic Training Facilities

I visited two formal Prosthetic & Orthotic training facilities. I was given a tour of the facility and gained and understanding of the requirements for entry into the programs and the process of becoming a Certified Prosthetist (CP) or Certified Orthotist (CO). I found many variations existed between America, Canada and Australia.

The two facilities visited were

- The Northwestern University Medical School, Prosthetic & Orthotic Center, Chicago
- The George Brown College – Prosthetic & Orthotic Program, Toronto

I was invited to give a lecture to the final year students at the George Brown College on the Australian Prosthetic & Orthotic profession and Churchill Fellowship. It was nice to be able to share some information with students from afar. I was often interacting with P&O undergraduates on placement at many of the facilities visited. Most departments were involved in the formal aspects of providing clinical and technical experience for under graduates, similar to the National Centre for Prosthetics & Orthotics program in Australia.

The Team Approach

The close interaction and communication of the multidisciplinary team encountered in the facilities and departments visited ensured patients were receiving optimised and coordinated treatment programs. There are many health professionals who all contribute to the overall care of the cerebral palsy affected child. Each professional has their own particular expertise in managing this difficult and challenging condition. The typical group of health carers for the cerebral palsy affected child could include:

- Physiotherapist
- Occupational therapist
- Speech therapist
- Orthopaedic surgeon
- Paediatrician
- General practitioner
- Orthotist – Prosthetist
- Custom seating specialist
- Orthopaedic shoe manufacturer
- Podiatrist
- Social worker

The level of severity of the condition will determine how many medical disciplines are involved. From my observations at many of the leading paediatric institutions it was evident that the best care or management occurs when all members involved were all working together. When working as a team each person knows what the conjunctive treatments are. Communication is the key word that enhances group discussion and formulation of treatment plans as well as coordinating appointments and avoiding confusion of different information being given to the parents and child. Different professionals may not have the same goals, but the sum of all the goals should provide the best available care for the child.

Conjunctive or primary treatments available

My report focuses on orthotic management options and techniques. There are many Neuro developmental therapies available for the cerebral palsy affected child. This list, although not exhaustive, could include

- Neurotoxin administration
  - Botulinum toxin A (Botox), site specific injections
  - Intrathecal baclofen, administration via implanted pump
- Surgical procedures
  - Tendon lengthening
  - Osteotomy
  - Connective tissue release
  - Tendon transfers
- Custom pressure garments to influence positioning, ie Second Skin
- Physical therapy
  - Physical therapy programs
  - Progressive stretching programs
  - Progressive strengthening programs
- Orthotic
  - Application of orthoses for Activities for Daily Living (ADL)
  - Use of night splinting – stretch/maintenance
  - Post-operative protection, rehabilitation
  - Serial casting

Care provided – patient/parent relationship

The importance of personal relations with the child and the parent/carer cannot be underestimated. Trust, familiarity, respect as a clinician and a mutual relationship will be the underlying basis to ensure any treatments will be optimised. Communication will be enhanced with free discussion in regard to treatments outlined and more importantly when issues arise, like pressure areas from orthoses, should be addressed quickly and efficiently. Compliance of parents, to ensure clinician's recommendations are followed, will be more likely when the parent-professional relationship is positive. Children with congenital disabilities that require treatment of various forms will most likely be a regular patient to our clinics. The child has to have an affinity with the orthotist, which will make procedures required to provide orthoses a much easier task. Both child and parent/carer and orthotist will be involved in long term treatment when managing conditions such as cerebral palsy. The visit to the orthotist will hopefully not be a stressful outing.

Effectively meeting changes in condition

Parents, carers and therapists who have more contact time with the children are in the unique situation of being able to observe the dynamic physical changes as they occur. Orthotic treatment needs regular reviewing and prescription altering to meet the demands, or requirements to meet the challenges of the changes in physical condition. Orthoses are most commonly reviewed and repeated once the child grows out of them. On occasions orthoses may need to be reviewed and be altered before this occurs. It is often the carers and health professionals who are in more regular contact with the children who advise the orthotist of these alterations.

The orthotist often works closely along side the orthopaedic surgeons, who are regularly reviewing changes in the child's condition. The orthotist needs to be efficient in providing a timely service, particularly as orthoses are often an immediate adjunctive treatment following surgical procedures or neurotoxin administration. As the rehabilitation process progresses orthoses may need to be altered or re-prescribed more regularly to meet the fast changes during the rehabilitation process.

Adjunctive Therapy

Physiotherapists and Occupational Therapists provide ongoing maintenance to control the neuromuscular and physical side effects of cerebral palsy. Programs incorporating stretching, selective strengthening, balance and gait training are essential conjunctive therapies to maximise the potential of these systems. Parents and Physical Therapists who are more involved in intensive programs and have more contact with the children are in a unique position to be able to observe changes as they occur. It is important that effective communication between therapist, surgeon, parent and orthotist exists so timely prescription changes can be done to coincide with the dynamic changes that occur.

Dissemination of information

It has been difficult to summarise and condense three months of experience into one written report. I collected a large amount of valuable information during my Winston Churchill Fellowship. I have articles, information and photographs on each topic and facility I visited should any person wish to contact me for more information. The main method of dissemination of information will be through lecturing to various special interest groups. Several hundred photographs were taken and will form slide presentations for several different groups.

Planned lectures to date:

- Barwon Health – Geelong Hospital, Orthopaedic Unit
- Geelong Paediatric Physiotherapist special interest group (includes Shannon Park- Barwon Valley staff)
- Barwon Health - Geelong Hospital Paediatricians
- Physiotherapists – Barwon Health – Geelong Hospital and Grace McKellar Rehabilitation Centre
- Royal Melbourne Children's Hospital Orthotic department staff
- AOPA – Australian Orthotic & Prosthetic Association, Victorian and national opportunities
- Allied Health staff at the Geelong Private Hospital
- The Jack Brockhoff Foundation executive committee (sponsors of my Churchill Fellowship)

Future intentions

- Approach the National Center for Prosthetics & Orthotics (NCPO) at La Trobe University, Bundoora for a possible lecture for the P&O students.
- Continue to investigate individual areas of treatment and topics with the intention to write articles that summarise and make recommendations. These papers may be accepted into our professional newsletters.
- I will be making myself, my findings and information collected available to any persons interested.

Recommendations

I was exposed to many areas of new innovation and environments where I could compare and contrast the practices in North America with ours. It was encouraging to confirm that on the whole our current practices, clinical and technical are technologically abreast with those in North America. However there are several new and innovative techniques and practices I would like to pursue and implement into our clinics. The main area of new implementation will involve evaluating and introducing the NGAFO's and serial casting techniques for the cerebral palsy children we treat. Serial casting, in particular, will involve further investigation, discussion and close collaboration with other health professionals involved. We would develop and formulate our own protocols before implementation.

In summary areas I will be pursuing are the:

- Development and implementation of new treatment options
    - New Generation AFO's
    - Investigation of developing Serial casting program
    - Discuss Plagiocephaly with relevant medical staff, investigate current activity in Australia and possibility of development of protocols and introduction of technique when required
- Investigation of new product-component and implementation into current practises
    - Stance Phase control knee componentry
- Introduce new clinical and technical/workshop processes
    - Fibreglass impression casting
    - Introduction of laminates into current practises
    - Use of Check sockets for assessment prior to final prescription - manufacture

Conclusion

I would like to thank all who assisted in making my Winston Churchill Fellowship a rewarding and stimulating experience. I have gained many new relationships with colleagues and made new friends as well. The people I encountered were all very open and generous in sharing both their time and resources to ensure I was given the best opportunities to observe and learn about their practises. The willingness to share information to enable me to expand my professional expertise was appreciated.

It was easy to see that the people in our profession are passionate about their work and dedicated to assisting children with challenging and life long disabilities. The long term commitment to assisting and potentially improving an individual's life is very rewarding and satisfying one. Our children are important and it is a privilege to be in a position where we can make even a small difference to their lives.

My sincere thanks and appreciation go to Winston Churchill Foundation and the Jack Brockhoff Foundation for their financial assistance that made this Fellowship possible.

I would like to thank Mr John Miles (Winston Churchill Fellow – 1998) for introducing me to the Winston Churchill Fellowship program and assisting me in the application process for selection.

I would also like to thank my wife Sue and daughter Tess for their love and support that enabled me to spend two months travelling, many hours organising and arranging details prior to leaving, and to finalise this report.

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