The South African Society for Surgery of the Hand
Die Suid-Afrikaanse Vereniging vir Handchirurgie

SASSH
Trauma Course

3 - 4 March 1997

Arthur's Seat Hotel, Sea Point

Welcome

Dear Delegate

Welcome to the Mother City - and mother of all cities!

A special welcome to Professor Giorgio Brunelli and the Citizen Ambassador Program Hand Surgery Delegation. We hope you enjoy our course as much as Mother's attractions.

WIKUS DE JAGER
ORGANISER

Contents

Scientific Programme

Monday 3 March

07:30	Registration	
08:15	Welcome and announcement	*Wikus de Jager, Course Organiser*
08:20	Presidential address	*Ulrich Mennen*

Skin Cover
Chairman: John Fleming

08:30	Examination of the injured hand	*Martin Wells*
08:50	Discussion	
09:00	Fingertip Injuries	*Syd Biddulph*
09:20	Discussion	
09:30	Groin Flap	*Jan van Wingerden*
09:50	Discussion	
10:00	Radial Forearm Flap	*Wikus de Jager*
10:20	Discussion	
10:30	TEA	

Tendon and Nerve Injuries
Chairman: Wikus de Jager

11:00	Flexor Tendon Injuries	*Klaas Maritz*
11:20	Discussion	
11:30	Extensor Tendon Injuries	*K.S. Naidoo*
11:50	Discussion	
12:00	Rehabilitation after Tendon Injuries	*Corrianne van Velze*
12:20	Discussion	
12:30	Nerve Grafting Techniques	*Giorgio Brunelli*
12:50	Discussion	
13:00	LUNCH	

Amputations
Chairman: Jan van Wingerden

14:00	Amputations	*Theo le Roux*
14:20	Discussion	

14:30	Replantation	*Frans Duminy*
14:50	Discussion	
15:00	Upper Limb Prostheses	*Stephan Kritzinger*
15:20	Discussion	
15:30	TEA	

Chairman: Theo le Roux

16:00	Functional and Work Assessment	*Susan Bleloch*
16:20	Discussion	
16:30	Thumb Reconstruction	*Bennie Zeeman*
16:50	Discussion	

Tuesday 4 March
Chairman: Edward Bowen-Jones

08:00	Human Bites	*Archie Matime*
08:20	Discussion	
08:30	Gun Shot Wounds	*Mike Carides*
08:50	Discussion	
09:00	Brachial Plexus Injuries	*Giorgio Brunelli*
09:20	Discussion	
09:30	Hand Compartment Syndrome and Ischaemic Contracture	*Ulrich Mennen*
09:50	Discussion	
10:00	Management of the Swollen Hand	*Karin Weskamp & Susan Kleynhans*
10:20	Discussion	
10:30	TEA	

Chairman: K.S. Naidoo

11:00	Proximal Interphalangeal Joint Injuries	*David Rodseth*
11:20	Discussion	
11:30	Writing a Medico-Legal Report after Hand Injury	*Rael Jaffe*
11:50	Discussion	
12:00	Sports Injuries	*Wikus de Jager*
12:20	Discussion	
12:30	LUNCH	

Chairman: Ulrich Mennen

13:30	Spinal Cord Repair	*Giorgio Brunelli*
13:45	Discussion	
13:55	Nerve Repair and Regeneration	*Dimitrios Bourlos*
14:05	Discussion	
14:10	Reducing Tension at the Suture Line of Peripheral Nerves	*Johann G. Haas*
14:20	Discussion	
14:25	Neurovascular Island Flaps in Treatment of Finger Tip Injuries	*Triuwigis Wymer*
14:35	Discussion	
14:40	Direct Muscle Neurotization	*Luisa Monini*
14:50	Discussion	
14:55	TEA	
15:30	Case Discussion Please bring X-rays and/or slides Closure by the President, Ulrich Mennen	

EXAMINATION OF THE INJURED HAND
DR MARTIN C WELLS

It is essential to have a routine method of examination of the hand which covers all the functional elements of the different anatomical components in such a manner that any malfunction is recognised.

Urgent considerations: Make sure no other serious lifethreatening problems demand urgent attention. Once bleeding is controlled and the patient's vital signs are stable, the examiner may proceed with a systematic evaluation of the patient's hand injury. Maintain a quiet, reassuring atmosphere to relieve patient anxiety.

History: Note age, dominant hand, occupation, hobbies or sport, previous hand injuries (especially WCA cases). Regarding the injury, note mechanism of injury, magnitude of forces involved, position of hand during injury, potential for contamination (farm, industrial, injection). Note pre-existing medical problems, allergies, status of tetanus immunisation and time of last meal.

Physical examination: Observe the general disposition of the patient as a whole. Observe the hand in its resting position.

Cursory examination of active motion of the cervical spine, shoulder and elbow should be done to exclude proximal injuries.

Several things can be done at once, but for the purpose of illustration, a systematic approach will be used.

The skin is observed for wounds, lacerations, scars, colour, sweating, oedema, atrophy. Skin is palpated for temperature, sweating, mobility.

Finger nails noted for colour of nailbed, damage, subungual haematoma or foreign body. The vascular examination notes pain, function loss, skin colour, swelling.

The radial and ulnar pulses are palpated, arterial patency checked by the Allen's test. The pulp test for capillary filling must be carefully interpreted.

The skeletal system is observed for swelling and deformities of alignment, angulation and rotation. Palpate for point tenderness at radius, ulna, each carpal bone, intercarpal ligament and joint, radiocarpal joint, triangular fibrocartilage complex, midcarpal joint, distal radioulnar joint, carpometacarpal joints, metacarpals, phalanges, metacarpophalangeal (MP)joints and interphalangeal (IP) joints.

Joints are examined for active and passive range of motion (ROM), crepitus and stability. MP (in flexion) and IP (in extension) joints should be tested for stability of collateral ligaments. The thumb should flex, extend, abduct, adduct and oppose.

Wrist ROM includes extension, flexion, radial deviation, ulnar deviation, pronation and supination. Watson's test is used for scapholunate instability.

Each **flexor and extensor tendon** is examined with respect to excursion, triggering, crepitus or absence of function. Note PDS, EIP, EDM.

Examine the brachial plexus and the three main **nerves** involved individually, i.e. radial nerve, median nerve, ulnar nerve. Sensibility testing includes sweat observation, testing for light touch, two point discrimination and pain. Motor examination includes testing for each extrinsic and intrinsic muscle and grading from 0 to 5.

Routine and special **X-ray investigations** are used as indicated. Arthrography, CT scan, radionuclide imaging and MRI are seldom indicated.

FINGERTIP INJURIES
MR SYDNEY L BIDDULPH

Apart from the versatile mobility of the hand, the durable sensate finger tip must rank close to being most crucial in the stakes of importance.

The finger tip is truly the eye that sees in the dark and around corners. Unfortunately these precious areas run a high risk of being injured in both the work place and domestic surroundings.

On the volar aspect the durable highly sensitive pulp is found and on the dorsum, the equally important nail. The nail provides important protection to the finger tip. Both sides may be injured by sharp or crushing mechanisms and their treatment takes precedence over that of any underlying bony injury.

TREATMENT

Occasionally a grossly unstable fracture may need stabilisation using a K-wire. More often the fracture is stable or is stabilised by accurate repair of the soft tissue.

Thorough cleaning of the wound is essential to prevent secondary infection. Soft tissues, both pulp and nail bed, should be accurately pieced together. The nail should never be discarded but used as a splint - for both bone and nail bed.

AMPUTATIONS

Amputations of the finger tip should be classified into

(a) at the level of the nail

(b) proximal to the nail

(a) AT THE LEVEL OF THE NAIL

At this level, all remnants of volar pulp and nail bed should be preserved. Skin cover without bony shortening should be aimed at. Skin cover can be achieved by

1. split skin grafts
2. local flaps
   - advancement flaps
   - cross finger flaps
   - thenar flaps
   - island pedicle flaps
3. distant flaps

- Cross finger flap: It is a two stage procedure, which often results in unsightly scarring of the donor digits. Other disadvantages are that the transferred skin is insensate and hair bearing.

  Thenar flap: This is also a two stage procedure. As the finger is of necessity, held in acute flexion for 2-3 weeks, permanent contractures may result, especially in the over 40 age group.

  Sensitive palmar scarring may be a further complication. These 2 procedures may result in cold sensitivity in cold countries.

  Island pedicle flap: This is a complicated procedure which is usually reserved for resurfacing thumb lesions. It cassies significant donor digit mobidity.

One would try and avoid distant flaps or two staged flaps because of their inconvenience. Split skin grafts often result in unacceptable scar formation or may leave a fragile unstable surface incapable to live up to the demands of a manual worker. The triangular neurovascular flap is ideal under these circumstances. It is a one stage procedure involving one digit only. Further advantages are:

1. Provides normal durable sensitive skin
2. Adds length
3. Minimise parrot-beak deformation of the nail

(b) PROXIMAL TO THE NAIL

Once all pulp and nail bed tissue had been lost, there is seldom reason to augment skin cover by the use of complicated surgical procedures.

A slightly shorter finger with excellent skin cover is infinitely more functional than a longer stump with poor hypersensitive skin which may be adherent to underlying bone. In the case of the thumb all length is always preserved.

Free flaps and replantations are alternate possibilities which require special skills. There is an unacceptable high failure rate in the hands of inexperienced surgeons.

GROIN FLAP
DR JAN VAN WINGERDEN

THE RADIAL FOREARM FLAP
DR LT (WIKUS) DE JAGER

The radial forearm flap is a fasciocutaneous flap based on the radial artery. In the hand and wrist it is used as a reversed flap.

It was developed in China and further described by Yang et al in 1981, followed by Foucher in 1982.

INDICATIONS

Tissue loss on the dorsum of the hand and wrist with tendon or paratenon loss; bone exposed or skin loss extending over the MP joints.

The flap is thin and mobile and matches the texture of the dorsum of the hand well.

TIMED ALLEN'S TEST

It is essential that a timed Allen test is performed to assess the patency of the ulnar and radial arteries. This can be done intra-operatively in painful traumatised hands. In doubtful cases a Doppler can be used to confirm flow.

PROCEDURE

The radial artery is marked with the use of a Doppler. The pedicle length is measured from the radial styloid to the proximal extent of the skin defect. The flap is based one-third on the radial side and two-thirds on the ulnar side of the radial artery.

The flap is first dissected from the sides and then from proximally to distally to the APL tendons. The radial artery is clamped prior to division to confirm good flow to the flap and hand. Paratenon must be left on the tendons to allow skingrafting of the donor area. The radial nerve sensory branches are safeguarded.

In composite flaps the PL and BR tendons, radius boneblock or lateral cutaneous nerve of forearm or radial nerve sensory branches may be included. Bone and tendon grafts are done at the time of the flap.

The flap can also be done as a free flap, when the cephalic vein is included.

The flap may be passed subcutaneously using a pencil drain. Carefully avoid kinking or twisting of the pedicle.

ADVANTAGES VERSUS GROIN FLAP

1. Skin is thin and mobile
2. It has a better blood supply
3. It is an one-stage procedure
4. One night's hospitalisation is usually adequate

ADVANTAGES VERSUS FREE FLAP

1. Nearly no risk of re-exploration (versus 15%)
2. Shorter operating time
3. Shorter hospital stay (one versus five days)
4. Cheaper

DISADVANTAGES

1. The unsightly donor area can be covered with a long sleeve
2. Loss of the radial artery does not cause claudication
3. Hairiness in some cases

The radial forearm flap is ideal skin cover for the dorsum of the hand and wrist when the loss is too extensive to skingraft.

FLEXOR TENDON INJURIES
PROF NGJ (KLAAS) MARITZ

TENDON HEALING

Tendons receive nutrition through direct blood supply through the vincular systems and from synovial fluid. Lindborg demonstrated flexor tendon healing without any adhesion formation. Tendons heal as the result of intrinsic tendon cellular activity. Adhesions are not essential for nourishment.

It has also been shown that controlled passive motions help the quality of repair and stimulate the intrinsic healing capacity of the tendon. Thus the treatment of choice must be primary or delayed primary repair - with early active or passive motion.

PRINCIPLES

- All stab wounds and lacerations of the hand must be explored
- Repair as soon as possible
- Optimal conditions for surgery - lighting, theatre facilities, assistance etc
- Repair tendon sheath when possible
- Partially divided tendons:
  - less than 50%, epitendon only
  - more than 50%, Kirchmayer and epitendon stitch
- Prophylactic antibiotics
- Atraumatic technique
- Bruner zig-zag incision
- Repair both tendon whenever possible

SUTURING TECHNIQUE

Modified Kessler suture (Kirchmayer) with the transverse limb at least 1cm from the cut edge and in the volar avascular portion of the tendon, using 4/0 Ethibond or Nylon. This is followed by a running epitendinous suture.

Whenever possible, sheath incisions are best made at the level of the cruciate pulleys. It is important to preserve the A2 and A4 pulleys.

POST-OPERATIVE

A dorsal plaster splint with the wrist in 20° flexion, the MP joints 70-80° flexion and the PIP-joints straight. Plaster extends only to the PIP joints.

POST-OPERATIVE TREATMENT

Three methods are available:

1. Kleinert Method: Controlled mobilisation and dynamic splinting. McGrowther and Ahmed improved the method with a palmar pulley
2. Duran and Hauser Method: Controlled passive motion
3. Active movement from the beginning

We use a combined Kleinert/Duran method. Patients start exercising from the second post-operative day - rubber bands for 4 weeks, dorsal plaster slab for 6 weeks, protection for 3 months.

Results: 90% excellent to good results are possible.

FLEXOR TENDON GRAFTING

- Single stage tendon grafting: Indicated for the hand in good overall condition, with no extensive scarring, nearly full motion, satisfactory circulation, adequate skin cover and at least one intact digital nerve.

  The level of the lesion, the time since the injury and the number of fingers injured were not important factors as far as results were concerned.

  The palmaris longus is the best donor tendon. Graft up to the distal palmar region.

- Two stage flexor tendon grafting: Indicated for the fibrotic stenosed tendon sheath, a flex contracted finger with a scarred flexor tendon bed and loss of pulley. May also be considered in the acute setting.

  Stage I: Release of scar and joint contractures, reconstruction of pulleys, reconstruction of the neurovascular bundles and the insertion of the silicon rod up to the wrist. Early movement for the formation of a pseudo sheath.

  Stage II: Commenced when the patient has a soft supple digit with full passive motion. The silicon rod is replaced with a plantaris tendon. Distal osseous implant and proximal at wrist level Pulvertaft-type weave with most commonly the profundus tendon.

FLEXOR TENDON REPAIR IN CHILDREN

Primary repair. No benefit from early mobilisation. Post-operative immobilisation not to be continued beyond 4 weeks.

EXTENSOR TENDON INJURIES
PROF KS NAIDOO

SUMMARY

ANATOMY

Review of the functional anatomy of the extensor tendons especially

(a) Proximal forearm
(b) Extensor compartments at wrist
(c) Dorsum of hand
(d) Extensor expansion in the fingers

MECHANISM OF INJURY

Avulsion
Rupture
Laceration
Human Bite
Gunshort
Abrasion
Burns

PROBLEMS IN DIAGNOSIS

Missed injuries
Classical deformities

TREATMENT

Splintage of various types
K-wire stabilisation of joints
Surgical repair techniques
Surgical reconstruction

REHABILITATION

REHABILITATION AFTER TENDON INJURIES
MISS CORRIANNE VAN VELZE

Rehabilitation of patients with tendon injuries is one of the most frequent procedures performed by hand therapists and requires close co-operation between the patient, the surgeon and the therapist. The use of standard protocols is extremely valuable, since all members of the team are fully aware of their role during each phase of healing. A standard protocol should be developed by the hand team and should be reviewed periodically. Adjustments should be made according to own experiences as well as new information which has become available in the literature. However, it remains important to follow a protocol which works in a particular setting. It is no use to follow a protocol of early active motion after a flexor tendon repair if 90% of the patients live very far away and can only return for therapy every 2-3 weeks.

Although hand teams may follow a different protocol from the ones which will be discussed, the basic principles remain the same and can be incorporated in any proposed treatment protocol.

FLEXOR TENDON INJURY

Various protocols are advocated by different surgeons and therapists. The most important treatment options for the early phase of treatment (1-4 weeks post-op) are:

Immobilisation
Early controlled motion (active extension, passive flexion)
Early active motion
Passive motion

There are at least 8 criteria to keep in mind when a choice is made, including age, motivation and financial status of the patient.

These options will be discussed in detail, enabling therapists and surgeons to make an informed choice.

The second phase of treatment (weeks 4-6) is characterised by more active motion, but with the hand fully protected by a splint. Activities and therapeutic modalities include place and hold exercises, squeezing a sponge in water; ultra sound, gentle scar tissue massage are used during this phase.

In the third phase of treatment more stress can be applied to the finger(s). The patient may require a dynamic finger extension splint to decrease adhesions or to lengthen shortened tendons. Activities utilizing static grips may be used and gently passive movements are incorporated in daily activities.

During the last phase (weeks 10-12 post-op) a lot more stress may be placed on the hand and the patient usually returns to work.

EXTENSOR TENDON INJURIES

There are basically 2 ways to initiate rehabilitation after an extensor tendon injury, namely early controlled motion (passive extension and active flexion) and immobilisation. The latter method is the simplest to apply, but the disadvantage is that tendon adhesions may become quite a problem (although it is less of a problem on the extensor aspect than on the flexor aspect). Thereafter, the same phases of healing are followed as for flexor tendon injuries, namely protective phase, phase of light stress, phase of medium stress, normal use of hand.

Different modalities of treatment for each phase will be discussed and illustrated.

COMPLICATIONS

The 2 main complications which have quite a severe functional impact are: tendon adhesions and tendon ruptures.

Tendon adhesions require a tenolysis at approximately 6 months post-surgery. The secret of success is that active and passive mobilisation should be started on day one after the tenolysis. It is a painful process and local anaesthetic should be available during the first few days.

Tendon ruptures may occur during any phase of the healing process. Should the rupture occur within the first 6 weeks post-op, a secondary repair is often possible. Should it occur later, then the patient usually requires a second stage repair. This procedure requires a very specific treatment protocol.

COMBINATION INJURIES

Injuries which involve more than one type of tissue (eg a cut through the wrist, involving tendons, nerves, blood vessels and ligaments) usually present quite a challenge to the hand therapist, since there are so many more factors to consider. It is always a toss up between mobilisation and immobilisation and the rehabilitation process can be quite complicated.

NERVE GRAFTING TECHNIQUES
PROF GIORGIO BRUNELLI

AMPUTATIONS
DR THEO LE ROUX

Traumatic digital loss or amputation of a hand segment is a frequent occurrence; despite the ability to replant parts. Thousands of people have a permanent loss of some portion of their hand or arm.

Remember that a digit is part of a hand, that's part of a limb, that is part of a body and that is part of a person.

It is necessary to promptly formulate a plan that will result in restoration of optimal function for the patient and it is therefore very important to know the patient's occupation, dominance, hobbies etc. and his emotional attitude regarding the amputation.

An understanding of surgical indications and the basic principles of treatment is required, comprehension of the functional hand patterns and the consequences of amputation at different levels on the use of the remaining parts are essential.

Surgical management of an amputation requires careful planning with attention to technical details.

Always direct the post-operative therapy programme so that it will promptly improve the patient's condition so that he may return to work or enter into a vocational training program.

Remember that an amputation is not a failure for the doctor or the patient, but that it can speed up rehabilitation.

Cosmetic appearance cannot be taken lightly - body image is important for social relationship and acquiring a job - patients need psychological support.

Prosthesis are available whether functional or as a sleeve filler, the problem is sensory perception and usually needs visual control.

The problem with amputations is the multiplicity of techniques for the management, eg the management of finger tip injuries.

The message is to keep it simple with a good functional result.

The goals of amputation surgery in the upper extremity (Green) should be:

1. Preservation of functional length
2. Preservation of useful sensibility
3. Prevention of symptomatic neuromas
4. Prevention of adjacent joint contractures
5. Short morbidity
6. Early prosthetic fitting
7. Early return to work and play

The rest of the paper will discuss the different levels of amputations, surgical tips and the important rehabilitation of these injuries.

REIMPLANTATION
DR FRANCOIS J DUMINY

INDICATIONS

1. Amputation of a functionally significant digit/limb segment/body part
2. Amputated tissues not crushed or otherwise severely damaged
3. Amputation stump not crushed or otherwise severely damaged
4. Patient healthy and fit enough to undergo prolonged surgery
5. Amputation of anything in a child

Clear indications for Reimplantation

1. Thumb, index finger (or more) in young healthy adult non-smoker
2. Amputation of anything in a child

Contra-indications for Reimplantation

1. Patient with chronic illness eg diabetes, respiratory disease, heavy smoker
2. Severely damaged tissues in stump or amputated segment (including prolonged ischaemia)
3. Unmotivated, disinterested or unwilling patient

PRE-OPERATIVE MANAGEMENT

Emergency Care

1. Stop bleeding (elevation, pressure dressing/bandage)
2. Reassure patient and keep warm
3. Retrieve amputated segment
   - lightly rinse off any severe contaminants under running tap
   - place in clean dry container (eg plastic bag) and seal closed so that no water can get to the exposed tissues
   - float container in cold water with ice (NEVER on ice alone)
4. Arrange transfer to hospital with necessary facilities for reimplantation

Assessment

1. Haemodynamic status - ?resuscitated adequately
2. General health, fitness and habits (eg smoking)
3. Level and type of amputation - ?involving crushing force
4. Level of desire/motivation for reimplantation and its sequelae

Management

1. Keep patient warm and well hydrated
2. Discuss pros and cons of reimplantation with patient and family
   - long operation - hospitalisation (7-10 days)
   - success not guaranteed
   - long period of sensory loss - possible future cold intolerance
   - long rehabilitation and possible further tenolyses and neurolyses at later date
3. Hb (X-Match if <12g%), ECG, CXR
4. Pre-operative physiotherapy

OPERATIVE PROCEDURE

1. Debride and identify structures in amputated segment (usually before patient is anaesthetised)
2. Debride and identify structures in stump
3. Shorten bones appropriately to obtain adequate healthy vessel and soft tissue apposition
4. Order of repair is: bone fixation, tendon repair, venous anastomoses, arterial anastomoses, nerve repair, soft tissue closure

POST-OPERATIVE CARE

1. Keep patient warm and well hydrated
2. Low Molecular Wt Dextran (Rheo-Macrodex) 42ml/hr reduced over 5 days
3. Heparin 50iu/ml infusion into vein in reimplanted segment 5ml/hr
4. Monitor by Pulse-Oximeter where possible, otherwise colour, temperature and bleeding
5. Venous congestion - early application of leeches
6. Arterial occlusion - keep NPM, release dressings and soft tissue sutures - re-explore and re-do anastomoses
7. Early controlled mobilisation of uninvolved joints

FOLLOW-UP

1. Physiotherapy and occupational therapy regular including sensory re-education
2. May need Z-plasties to scar contractures and tenolyses
3. May need neurolyses if re-enervation delayed or if cold intolerance severe

UPPER LIMB PROSTHESES
MR STEPHAN KRITZINGER

Prosthetic solutions for the upper extremities

1. Suspension methods
   - harness
   - negative pressure
   - skeletal grip
   - silicon suspension
2. Power sources
   - body powered
   - hybrid
   - myo-electronic
   - switch control
3. Myo-electronic function
   - description

4. Cosmetic, cable controlled, hybrid and myo-electronic prostheses for
   - through shoulder
   - above elbow (trans-humeral)
   - elbow disarticulation
   - below elbow
   - wrist disarticulation
   - through hand
   - fingers
5. Children's prostheses
   - myo-electronic
   - aesthetical
6. Aesthetical prostheses
   - silicon manipulation technique
   - partial hand amputations
   - aesthetical prosthetic solutions
   - the value of finger prostheses
   - aesthetical and functional value

FUNCTIONAL AND WORK ASSESSMENT
MRS SUSAN BLELOCH

Rehabilitation following hand injuries/trauma can be a long and complex process and is not considered complete until the patient can participate in work activities. As a result, therapy programs that facilitate the performance of work activities have become an important component of the rehabilitation process. Over the years, numerous terms have been used to describe work-related programming including work hardening, returning to work programs, work conditions, work capacity testing, work tolerance training and work therapy. For consistency, the term "work therapy" will be used to encompass all terms referred to above.

The comprehensive work therapy program includes many phases and involves the co-ordinated efforts of the patient, therapist, physician, employer, insurance company and attorney where appropriate. Of primary importance in a successful return to work program, is the need to identify the functions which will be required of the patient in order for him/her to perform his task at work successfully. For this, it is necessary to examine and document the types of tasks and levels of competency required to fulfil them.

Once the patient's job requirements are identified, a therapy program is designed to improve his/her flexibility, strength, endurance and co-ordination for job tasks. Ideally, the goal of the work therapy program is to return the patients to their previous occupation. When this is not possible, job modifications are considered. The success of any hand therapy program should be gauged not only by gains in strength and range of movement measurements, but also by the extent to which the patient can return to his/her original occupational or work related tasks.

It is necessary to employ standardized measuring assessment techniques with which to quantify the patient's functional capacities. One such system is the WORK CAPACITY EVALUATION (WCE), also known as the physical capacity or functional capacity evaluation. This assesses the patient's physical capabilities and limitations with regard to work. The WCE has 5 components: medical and work history, hand function, standardised testing, physical demands of work and effort consistency.

The WCE is completed at the end of the therapy program to determine the patient's ability to return to work. The importance of incorporating standardised tests in a WCE cannot be overestimated. The results from these tests validate conclusions and recommendations, and their use increases the validity of the WCE.

Many tests are available. The Valpar Sample Assessment Tools, for example, are a group of tests which provide scores calculated from assessments of normal working populations. By comparing the patient's scores against these norms, the therapist can determine how competent the patient will be in the workforce.

Each WCE is case-specific and differs depending on the purpose of the evaluation, the condition of the patient and the occupation to be performed.

Functional and work assessment leading to the rehabilitation and return of the patient to the workplace after hand trauma, is becoming increasingly important in the light of new labour legislation in South Africa. For the first time, South African legislation is in the process of being developed to uphold the rights of people with disabilities to non-discrimination and equal opportunities in the work place. This new legislation offers occupational therapists the opportunity to promote the spirit, intent and objectives of human rights legislation and to prohibit unfair discrimination of impaired citizens on the grounds of disability. The new laws establish occupational therapists as key role players, and will render their services indispensable to hand trauma patients now and in the future.

THUMB RECONSTRUCTION
PROF BENNIE ZEEMAN

HUMAN BITES
DR ARCHIE MATIME

The incidence of human bite injuries to the hand will naturally vary from one community to the next. However, it is universally accepted that whenever it occurs, this is a serious injury, which requires a good understanding of the pathological process in order to offer reasonable treatment to the victim.

The treatment is aimed at avoiding any of the possible complications: severe sepsis with chronic swelling and stiffness, osteitis, pyogenic arthritis, spreading infection with various levels of amputation and loss of function.

Almost without exception, the treatment of all human bite injuries to the hand require emergency, careful and adequate surgical debridement with non-closure of the wound primarily; copious lavage; prophylactic antibiotics and frequent review; and lastly a supervised rehabilitation program, which should be part of the primary treatment, not to be relegated to the end when the wound has healed. If any of these treatment principles are compromised, or the patient presents late, the results are predictably poor.

GUNSHOT INJURIES
DR MICHAEL CARIDES

The kinetic energy and thus wounding potential of a missile varies with its mass and with the square of its velocity. Low-velocity gunshots are defined as having a muzzle velocity of less than 600 m/sec. Most civilian handguns and rifles, including .22, .32, .38 and .45 calibre weapons, inflict low velocity injuries. Only certain hunting and military rifles have muzzle velocities of over 700 m/sec

and are classified as high velocity weapons. Although shotgun pellets are technically low-velocity projectiles, close range shotgun blasts produce wounds similar to and should be treated the same as those produced by high-velocity bullets. Temporary cavitation does not occur in the low-velocity wound and tissue damage is confined to the projectile pathway. Extensive debridement is not indicated for these injuries and local wound care with skin cleansing and ellipsing of the skin edges is sufficient. The high-velocity bullt, however, causes devastating injury with extensive wound cavitation and distant tissue necrosis. Established wound protocol for these hand injuries includes classical debridement with enlaring incisions, excision of damaged and devitalised tissue, evacuation of haematome, copious irrigations and loose or delayed closures with high dose antibiotic cover. All patients should be examined for other injuries and resuscitated where necessary. Tetanus prophylaxis is mandatory. If massive swelling is present, fasciotomies of the intermetacarpal fascial compartments and release of the carpal tunnel should be considered. Definitive fracture management should be carried out early to allow for active mobilisation of the hand as soon as possible.

Where segmental defects of bone are present, bone graft should be performed, preferably as a delayed primary procedure within 10 days of injury. Complex joint injuries often result in bony or fibrous ankylosis and should be immobilised in the position of function.

Primary tendon and nerve repairs may be performed depending upon tissue damage and contamination, but grafting must wait until soft tissue healing is complete. All hands should be elevated post-operatively and physiotherapy started as early as wounds will allow. Even with optimal treatment, however, the incidence of salvage surgery and amputations with these injuries is high.

BRACHIAL PLEXUS INJURIES
PROF GIORGIO BRUNELLI

HAND COMPARTMENT SYNDROME AND ISCHAEMIC CONTRACTURE
PROF ULRICH MENNEN

DEFINITION

Compartment Syndrome (C.S.)

An increase in pressure in a closed compartment, eg muscle and nerve results in a group of symptoms and signs which reflects the compromised bloodflow in that compartment.

Volkmann's Ischaemic Contracture (I.C.)

An unattended compartment syndrome results in tissue necrosis, which is replaced by fibrous scar tissue which in return ends with tissue shortening (contracture) and function loss (motor and sensory).

ETIOLOGY

The many causes of C.S. can be divided into 3 groups:

1. Decreased compartment volume
   e.g. excessive traction on a fracture
2. Increased compartment content
   e.g. bleeding (haematoma, coagulation defects, anti-coagulant therapy) oedema (contusion, reperfusion, exercise, snake- and insect bites, venous obstruction, infection, tourniquet, high pressure injections, extravasation of drugs, gunshot injuries, capillary leak, electrical injuries)
3. Externally applied pressure
   e.g. tight dressings, casts, lying on limb

PATHOPHYSIOLOGY

Any of the etiological factors gives the same result, eg reduced capillary bloodflow in <u>all</u> the affected tissues, ie muscle, nerves, tendons, etc.

Ischemia progresses to tissue death, which is replaced by fibrous scar tissue ending in contractures and function loss. The dead tissue gives rise to myoglobinuria and renal failure, hyperkalemia and cardiac irritation. These serious conditions need special attention, eg diureses. Under certain severe conditions, eg high voltage electrical injuries, the C.S. should be regarded as a crush syndrome and an emergency amputation may be indicated.

DIAGNOSIS

C.S. is diagnosed clinically. A high index of suspision, combined with a keen clinical judgement has a much higher accuracy rate than fiddling with pressure measurements. Too many variables makes pressure measurements inaccurate and cumbersome and therefore dangerous for general use. It is therefore not discussed further. Some 10 clinical symptoms and signs should easily enable the clinician to diagnose an impending C.S. Always compare with the patient's other side.

1. Pain (ischemic)
2. Colour (blue or white)
3. Temperature (low)
4. Swelling
5. Function loss
6. Sensation loss (paraesthesia, anaesthesia)
7. Stretch test
8. Capillary perfusion (pulp, nailbed)
9. Sweat
10. Digital filling
11. Pulse (deceptive !)

I.C. is one of the most dreaded conditions seen by hand surgeons. Before I.C. sets in, i.e. established C.S., the typical position of the hand and arm is attained: fore-arm in pronation, wrist in flexion, MP joint in hyper extension, PIP and DIP joints in flexion, and loss of sensation in the median and ulnar nerve distribution. Once I.C. is established, muscles and nerves are replaced by fibrous tissue, severely compromising function of that limb.

Of course, this scenario occurs if gangrene has not set in. It is not too uncommon to amputate a limb for gangrene especially in children after so-called minor trauma, eg greenstick fracture of the radius and ulna.

TREATMENT

A thorough knowledge of the anatomy of the affected section would make the diagnosis of a particular muscle, muscle group or a compartment much easier. The treatment is very simple: release the pressure in the affected compartment by opening (fasciotomy) the restricting cover (skin, deep fascia and epimysium).

This is done by direct incision of the fascial layers (or in the lower limb, by removing the fibula). It is important to make the skin incision wavy or curved to prevent scar contracture later on. Try and avoid damaging the cutaneous nerves and veins. Incisions should be adequate eg in the forearm the cut is made from above the elbow to into the palm, including the carpal tunnel. Decompressing the intrinsic muscles can easily be achieved by 2 incisions on the dorsum of the hand, whereas the thenar and hypothenar muscles are approached by an incision over the muscles where the volar and dorsal skin meets. Fingers are approached again from lateral, where dorsal and volar skin meets, making sure not to damage the neurovascular bundle.

Skin closure is done as soon as the swelling subsides, often direct suture is not possible, and a split-skin graft may be indicated.

Post-op management includes Jelonet dressings, covered with an antiseptic such as Acroflavin, splinting in the functional position, elevation to about 15cm above heart level, antibiotics, anti-inflammatories for pain and swelling and careful hand therapy.

Late reconstruction or surgery to regain function, falls outside the scope of this presentation. These would include hypertrophic scar revision, contracture release, muscle slide procedures, tenotomies, tendon transfers and even free muscle transfers.

SPECIAL CONDITIONS

Some causes of C.S. need special mentioning:

1. **Prophylactic Fasciotomy.** This should be done at the time of reperfusion procedures, eg embolectomy, arterial anastomoses and prolonged compression.
2. **High voltage electric injuries.** These injuries often show minimal external damage, since the electric current passes via high water content tissues, eg muscle, blood vessels and nerve. Discression is essential to decide between fasciotomy, excision of necrotic (chared) tissue and amputation.

3. **Snake bites.** In South Africa, those patients who make it to hospital, usually were bitten by snakes with tissue necrotizing poison . Arms swell greatly and may be saved by amongst other treatment, prophylactic fasciotomy. In children, because of the small tissue volume of their upper limbs, the amount of poison is too much for the arm and "spills over" into the lungs, causing severe oedema and respiratory distress syndrome.

4. **Insect and scorpion bites.** The type of insect is not always known and a general approach is often the only way to deal with the painful bite which gradually enlarges due to oedema (inflammation). In small children this may reach limb threatening proportions. Again, general rules apply: moderate elevation, anti-histaminics, anti-inflammatories, antibiotics, steroids and fasciotomy.

5. **High pressure injuries.** This is seen with spray gun injuries. The type of paint or chemical will determine the severity of the inflammatory response. Apart from standard measures, very careful debridement and neutralization of the chemical is indicated.

6. **Gunshot wounds.** Apart from the direct injuries caused by the bullet, the shock wave causes severe tissue damage resulting in swelling and C.S. Prophylactic decompression is often necessary and should include the major nerves which are in dose proximity. One often sees severe bleeding and bruising in the nerve and a simple epineurolysis may prevent intraneural fibrosis at a later stage.

FURTHER READING

Green, DP (Editor): "Operative Hand Surgery". Chapter 19, 3rd Edition. Churchill Livingstone.

Mennen, U (Editor). "The Hand Book". Chapter 2, 11, 2nd Edition. J.L. van Schaik Publishers.

Mennen, U. "Compound injury from high voltage electricity." SA Journal of Surgery, 1989, 179-181.

THE SWOLLEN HAND - AN OCCUPATIONAL AND PHYSIOTHERAPY PERSPECTIVE
MISS KARIN WESKAMP AND MRS SUSAN KLEYNHANS

A swollen hand is uncomfortable, mostly painful and often functionally limiting. The increase in pressure in the tissue reduces movement and if left untreated, develops into fibrous tissue. This impairs hand function which has a devastating effect on the person's day to day functioning. Active treatment must commence as soon as possible to reduce swelling quickly and efficiently.

Although the principles of treatment are similar, there are different kinds of swelling and therefore different approaches and techniques to treatment. Elevation of the hand should continue both when the patient is in bed at night and during his waking hours. Active movement, massaging, bandaging, compression and galvanic stimulation are all useful and effective treatment modalities. Pain should always be taken seriously as it is a very real and unpleasant actuality for the patient. Causing the patient too much pain can worsen rather than improve the condition.

Splints are used to maintain what the patient has gained during therapy. The correct choice of splint/s is important because if used incorrectly, the splint/s can do more harm than good.

At all times it is important to communicate with the patient. Explanation of the condition, treatment techniques used, correct wearing of splints and discussing treatment outcome need to be ongoing. Better understanding produces better compliance produces better outcomes which produces FUNCTION.

PROXIMAL INTERPHALANGEAL JOINT INJURIES
DR DAVID RODSETH

The PIP joint has been called the epicenter of hand surgery (R. Curtis). "Nowhere else is anatomy and function so interrelated." (Urist).

Injury to these joints is not uncommon and the challenge is to obtain a functional range of motion in a painfree stable joint. Soft tissue and bony injuries present problems in our effort to achieve a satisfactory result and some of the more common injuries tc this joint will be discussed with various treatment options.

WRITING A MEDICO-LEGAL REPORT AFTER HAND INJURY
DR RAEL JAFFE

The assessment of a hand injury for medico-legal purposes is of vital importance and it is the duty of the profession to the public to address this seriously.

The usual reasons for a report are litigation after an MVA, an injury in a public building or thoroughfare and by a patient against a medical practitioner.

One must always be unbiased and honest as the consequences can be serious both for the client and the surgeon.

In preparing the report one must have a careful interview with the patient, taking a detailed history of the injury as well as its treatment followed by obtaining the current complaints of the patient. A careful examination with special investigations such as x-rays, electromyography and tests of hand function completes the interview.

Reference to an occupational therapist for further assessment of loss of function and work possibility may be indicated.

The CONCLUSIONS should cover:

(a) A detailed assessment of the functional loss and permanent disability together with an outline of the further treatment of the injury
(b) The length of temporary and permanent disability and an appraisal as to whether the patient can return to his own previous work or alternate employment
(c) Recreational and sporting activities
(d) Pain and suffering
(e) Scarring and disfigurement
(f) Future medical expenses

Before preparing the report, one should do the relevant research and refer to the literature.

Evidence is often required in court leading from the above report.

A pre-trial consultation is mandatory to clear up any misunderstanding before the trial with counsel.

Often a joint consultation with a specialist from the opposite side is helpful and may avoid both having to attend a court hearing by coming to a joint agreement.

In court one should be clear and simple and use aids such as x-ray models to simplify the problem.

SPORT INJURIES OF THE HAND AND WRIST
DR LT (WIKUS) DE JAGER

Each sport has its own pattern of injuries which are not necessarily unique to that sport, eg FDP avulsions in rugby or mallet fingers in cricket. Certain injuries are unique to their sport, eg A2 pulley rupture in rock climbers, the gymnast's wrist of the weight lifter's wrist.

Protective clothing should be encouraged at all levels in the sport. The timing of return to sport is based on a combined decision between the patient and the treating doctor, weighing up the risk of re-injury, worst case scenario and the effect on the sportsman's career.

SPINAL CORD REPAIR
PROF GIORGIO BRUNELLIpo

NERVE REPAIR AND REGENERATION
DR DIMITRIOS BOURLOS

After peripheral nerve transection, the portion of the axon proximal to the injury remains viable, due to the bidirectional axoplasmic transport of materials. The parent neuron responds to injury by increasing production of materials needed for axon elongation; growth associated proteins; actine and tubulin. Production of neuroflament is decreased. These molecular changes result in the cell body reaction, manifested by increase in size of nucleolus, eccentricity of the nucleus and clumping of chromatin. Distal to the site of transection, the axon no longer communicates with the parent neuron and viability is lost. Axoplasm and myelin are cleared from Scwann cell tubes through the process of Wallerian degeneration. Influx of calcium triggers granular degeneration of the axoplasm, then circulating macrophages are recruited to aid the proliferating Schwann cells in digestion of myelin. At the completion of this

process, the Schwann cell tube is empty except for a longitudinally arranged chain of Scwann cells, the band of Bunger, which serves as an ideal substrate for axon regeneration. The regenerating unit is formed from multiple collateral sprouts, from the transected axons, crosses the site of nerve repair and enters the Scwann cell tubes of the distal nerve stump. These collateral sprouts regenerate distally at the rate of 1 to 2 mm/day in primates. Most often only the collateral sprout from each axon survives. Motor axon collaterals are more likely to survive in Schwann cell tubes that previously contained motor axons and lead to muscle and to be prune from tub es that lead to skin. The process of collateral pruning may thus be used by the organism to save collaterals that will restore function at the expense of those that will not. At the completion of regeneration the surviving axon will be smaller than normal caliber and will be less thickly myelinated so conduction velocity will be reduced. A short description of the current surgical techniques follows.

REDUCING TENSION AT THE SUTURE LINE OF PERIPHERAL NERVES
DR JOHANN G HAAS

The results with nerve sutures are generally better than with nerve grafts, where sutures are feasible. But undue tension prohibits suturing, so in large defects nerve grafting is the method of choice. However, with the numerous moderate-sized defects after resection of nerve ends and in particular in secondary treatment where the nerve stumps are less elastic, suturing would be possible if the tension at the suture line could be reduced.

To achieve this, we are us not elastic ribbons of resorbable PDS (Polydioxanon), 20mm in length and 1mm in width which are sutured to the epineurium at both sides of the nerve, thus bridging the suture site to keep it tension free in a form of "splinting". Early mobilisation of the adjacent joints is possible. As the peripheral nerve is living tissue and not only a physical conduit, the limits of stretching are to be respected to avoid any hazard to blood circulation and nerve function. Therefore the method is limited to very common defects of up to 25mm of injured nerve trunks, eg median or ulnar nerves.

The ribbons become adherent to the epineurium, distributing the tension over their whole length. The line scar remaining after their resorption maintains protection of the suture line. It has been validated experimentally that with this method the load applied to sutured nerve segments can be noticeably increased even immediately after suturing, before separation will become visible.

Comparing cases with similar moderate-sized reinnervation was better with coaptation of the stumps using these microbands than with nerve grafting. In more than 100 patients we did not see any post-operative complications due to the PDS material. Thus, in well-fitting cases of nerve injuries the time-consuming procedure of nerve grafting can be avoided, together with a possible donor site morbidity and the risk of mismatching of the fascicles, problems which are more likely to occur with nerve grafting than with direct coaptation of the nerve stumps.

The method can augment indications for primary or secondary coaptation without grafts. But it does not provide better results in nerve injuries with tension-free primary sutures. Here reinnervation depends only on the other pre-requisites of successful surgery, such as correct alignment of the fascicles and sufficient hemostatis, in order to obtain the best conditions for axon sprouting and neurotropic action.

NEUROVASCULAR ISLAND FLAPS IN TREATMENT OF FINGER TIP INJURIES
DR TRIUWIGIS WYMER

The results of 50 cases are demonstrated.

TYPE OF INJURIES

Loss of soft tissue and bone in the distal phalanx of thumb and long fingers caused by clear cut or contusion at home or at work.

OPERATION TECHNIQUE

Triangular or rectangular tissue compartments, based on both palmar neurovascular bundles, were advanced into the defect after microsurgical dissection. (Modified Tranquili-, Leali-, Cutler- or Moberg technique). Distal advancements of 10-20mm were possible.

Follow-up examinations were done after 6 weeks, 3 months and 6 months.

The late results (after 6 months) are discussed under the following aspects:

1. post-operative complications
2. 2-PD
3. range of motion in DIP
4. power of pinch grip
5. nail growth
6. scars
7. use of finger in private life
8. use of finger at work

RESULTS		**No of cases (50 = 100%)**
ad 1)	Moderate wound infections	18
	Delayed wound healing between distal end of flap and nail bed	16
	Superficial skin necrosis (No loss of flap)	9
	Average time of complete wound healing 24 days	
ad 2)	No difference to contralateral finger	32
	2 PD 8-10mm	12
	> 10mm	6
ad 3)	No loss of power in pinch grip (compared with contralateral finger)	33
	Loss of power - 10%	12
	- > 10%	5
ad 4)	Moderate bulging of the nail in all cases (caused by loss of splinting effect of bone)	
ad 5)	Painful scars	--
	Hypertrophy of scars	--
ad 6/7)	Finger useful at home and at work (Used in all types of grip: pinch-, key-, hook-, power-)	48
	No use 2	

CONCLUSIONS

Neurovascular island flaps are a useful part of the operative treatment of finger tip injuries. They are first choice in cases of partial amputation of the distal phalanx, with free bone, where split skin grafts are not possible.

Shortening of the bone is not necessary. The sensibility is good.

Our results in 50 cases were good.

DIRECT MUSCLE NEUROTIZATION
DR LUISA MONINI

Direct muscular neurotization is a surgical procedure which implants into a denervated muscle, a nerve connected with the proper nerve of the muscle or with a different nerve.

Indications for this technique are: avulsion of the nerve from the muscle, destruction of the terminal branches, traumatic or surgical removal of the neural part of the muscle.

The biological basis allowing this reinnervation are: the possibility of a denervated muscular fibre to accept a new innervation due to the spreading of acetilcholine receptors all over the fibre after denervation and the capability of forming new motor end plates by motor nerve fibres when in contact with a denervated muscular fibre.

A large series of clinical cases has followed long animal research with very good and good results.

Address List of Speakers

Bleloch, Mrs Susan	PO Box 41086 CRAIGHALL 2024 Tel (011) 7834231 Fax (011) 8839611
Biddulph, Dr Sydney L	PO Box 1270 HOUGHTON 2041 Tel (011) 4873000 Fax (011) 4871828
Bourlos, Dr Dimitrios	Zakinthinou 45; Papagos 15669 Athens GREECE Tel +301 7786972 Fax +301 7798511
Brunelli, Prof Giorgio A	Universita Degli Studi di Brescia Clinica Ortopedica Presso Spedali Civilli; Piazzale Ospodale Civile 2 Brescia ITALY 25124 Tel +3930 3995401 Fax +3930 393832
Brunelli, Ms Luisa M	Campiani 77 Cellatica 25050 ITALY
Cårides, Dr Michael	Suite 22, 2nd Floor Rosebank Clinic 14 Sturdee Avenue ROSEBANK 2196 Tel (011) 4474481/1 Fax (011) 4474488
De Jager, Dr LT (Wikus)	Hand and Upper Limb Unit Vincent Palotti Hospital PINELANDS 7405 Tel (021) 5313621 Fax (021) 5313621

Duminy, Dr Francois J	Bow Cottage 4 Wilderness Lane CLAREMONT 7700 Tel (021) 6833048 Fax (021) 6835126
Haas, Dr Johann G	Atzelbergstrabe 133 Frankfurt am Main GERMANY D-60389
Jaffe, Dr Rael	204 Fairfield Medical Suites Wilderness Road CLAREMONT 7700 Tel (021) 616513 Fax (021) 642875
Kleynhans, Mrs Susan	Hand and Upper Limb Unit Vincent Palotti Hospital PINELANDS 7405 Tel (021) 5310443 Fax (021) 5313621
Kritzinger, Mr Stephan	Suite 202 City Park Two 162 Longmarket Street CAPE TOWN 8001 Tel (021) 244345 Fax (021) 244346
Le Roux, Dr Theo LB	PO Box 32965 GLENSTANTIA 0010 Tel (012) 3140999 Fax (012) 3291517
Maritz, Prof NGJ	Dept of Orthopaedic Surgery HF Verwoerd Hospital Private Bag X196 PRETORIA 0001 Tel (012) 3546528 Fax (012) 3546164

Matime, Dr Archie M	PO Box 59631 KARENPARK 0118 Tel (012) 3225191 Fax (012) 3206168
Mennen, Prof Ulrich	Dept Hand- and Microsurgery PO Box 186 MEDUNSA 0204 Tel (012) 5294219 Fax (012) 5294219
Naidoo, Prof KS	Dept of Orthopaedic Surgery Private Bag 7 CONGELLA 4013 Tel (031) 2604374/2604293 Fax (031) 2604518
Rodseth, Dr David	Dept of Orthopaedic Surgery Tygerberg Hospital TYGERBERG 7505 Tel (021) 9385458 Fax (021) 9317810
Van Velze, Ms Corrianne	PO Box 846 GROENKLOOF 0027 Tel (012) 3462700 Fax (012) 3462700
Van Wingerden, Dr Jan J	PO Box 27324 SUNNYSIDE 0132 Tel (012) 3438333 Fax (012) 3438666
Wells, Dr Martin C	117 Panorama Medi-Clinic Rothschild Boulevard PAROW 7500 Tel (021) 9304970 Fax (021) 926914

Weskamp, Ms Karin	Hand and Upper Limb Unit Vincent Palotti Hospital PINELANDS 7405 Tel (021) 5310443 Fax (021) 5313621
Wymer, Dr Triuwigis W I	Dept for Hand Surgery Katharinen-Hospital Unna; Obere-Husemann-Str 2 59423 Unna GERMANY
Zeeman, Prof Ben J van R	Dept of Plastic Surgery Faculty of Medicine University of Stellenbosch PO Box 19063 TYGERBERG 7505 Tel (021) 9389585 Fax (021) 9317810

Trade Exhibitors

Ian C Baillie & Associates

Macromed cc

Medac

Nedbank

Scipharm

Smith & Nephew Limited

Stratmed

Acknowledgements

We are grateful to the following companies for their generous sponsorships:

Eli Lilly

Stationery

Stratmed cc

Audiovisual

Notes

Notes

Notes