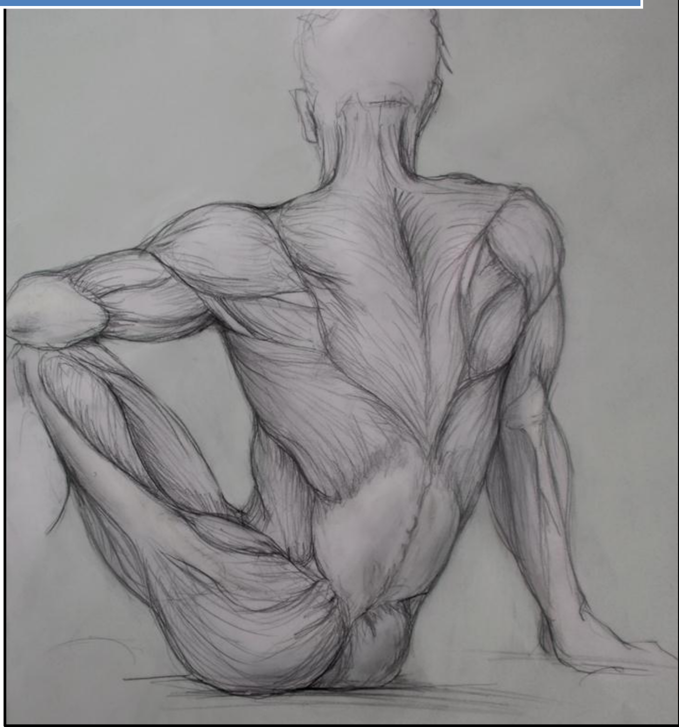
Impairment and Disability Short Course
19 April 2013

Physiotherapy in Burns, Plastics and Reconstructive Surgery



Aoife Hale

Rhona O'Donovan

Sarah Diskin

Sarah McEvoy

Claire Keohane

Geraldine Gormley

PY4017/4019

Module Leader: Norelee Kennedy

UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

Preface

This booklet is the culmination of our research in relation to best practice for Physiotherapists working in the area of Burns, Plastics and Reconstructive Surgery. It should be used in tandem with our presentation. It is not an exhaustive source, and should be used in conjunction with the referenced materials and any new research which may emerge in the future. It is not intended as a replacement for clinical reasoning, but to aid you in the process of your assessment and treatment planning and execution.

Acknowledgements

We would like to thank the following specialists who contributed their guidance and knowledge in the completion of this project Catherine O'Sullivan, Senior Physiotherapist UCHG, Alesha Kelly, Senior OT, UCHG, Fionnuala Cassidy, Senior Occupational Therapist in Burns, St James' Hospital Dublin, and Kirstin Aschbacher, Senior Psychologist University College San Francisco. We are grateful for the guidance and advice provided by Norelee Kennedy, our module leader and to Oliver McGarr whose new perspective and guidance was invaluable in the creation of our presentation. Finally, thank you to Brian Stewart for his help in editing our video case study.

Contents

Abbreviations

ACL: Anterior Cruciate Ligament
ADL: Activities of Daily Living
ANZBA: Australia and New Zealand Burns Association
AROM: Active Range of Movement
BBA: British Burns Association
BSHS Burn Specific Health Scale
BSHS-A: Burn Specific Health Scale Abbreviated
BSHS-R : Burn Specific Health Scale-Revised
CBT: Cognitive Behavioural Therapy
DASH: Disability of Arm, Shoulder and Hand Index
DIP: Distal Interphalangeal
DVT: Deep Vein Thrombosis
EAM: Early Active Movement
ETR: Extensor Tendon Repair
FDP: Flexor Digitorum Profundus
FDS: Flexor Digitorum Superficialis
FEV1: Forced Expiratory Volume in 1 Second
FTR: Flexor Tendon Repair
FTSG: Full Thickness Skin Graft
HEP: Home Exercise Programme
HRM: Heart Rate Max
HRQOL: Health Related Quality of Life
IAPS: Irish Association Of Plastic Surgeons
IES: Impact of Event
LBM: Lean Body Mass
LL: Lower Limb
MCP: Metacarpophalangeal
MDT: Multi Disciplinary Team
MET: Metabolic Equivalent
NIMH
OCM: Outcome Measures
OT: Occupational Therapist
PGT: Pressure Garment Therapy
PIP: Proximal Interphalangeal
POSAS: Patient Observer Scar Assessment Scale
PROM: Passive Range of Movement
Pt: patient
PT: Physiotherapist
PTSD: Post Traumatic Stress Disorder
QOL: Quality of Life
RCT: Randomised Controlled Trial
ROM: Range of Motion
RPE: Rate of Perceived Exertion
Rx: Treatment
STSG: Split Thickness Skin Graft
TAM:
VAS: Visual Analogue Scale
VBSS: Vancouver Burn Scar Scale
WBC: White Blood Cells
WTQ: Work to Quota
WTT: Work To Tolerance

Part 1

Physiotherapy in the Rehabilitation of Burn Injuries

Section 1: Introduction

Thermal injuries are a common occurrence, which are accompanied by a high risk of mortality and morbidity amongst all age groups.

1.1 Epidemiology

- Total of 4,563 hospital admissions for burns between 1993 and 1997
    - 25.3 per 100,000 population
- The Bradford Burn Study (Khan et al 2007)
    - Studied all burns admissions (n=460) for a full year at a single A&E in the UK
    - Children of <10 years accounted for 36% of admissions
    - Wrist and Hand burns accounted for 36% with upper limb burns constituting a further 21% (DORAS 2001)

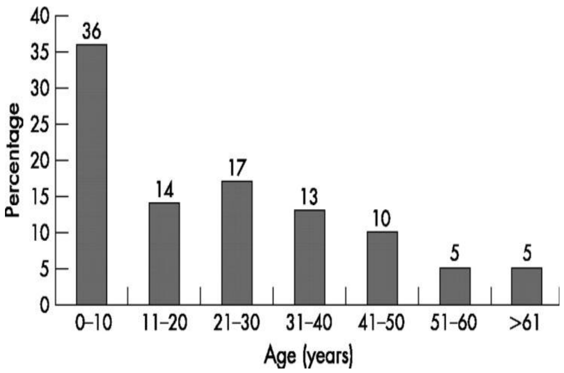


Figure 1. Percentage of burn incidents versus age.

(Khan et al 2007)

1.2 Mechanism of Injury

(DOH, Western Australia 2009; Ever et al 2010; Hettiaratchy and Dziewulski 2004)

- May be thermal or non-thermal
    1. Flame burns – 50%
    2. Scalds from hot liquids, e.g. boiling water, cooking oil – 40%
    3. Contact burn, e.g. stoves, heaters, irons,
    4. Electrical burn, e.g. electrocution
    5. Chemical Burns, e.g. Hydrofluoric Acid
    6. Friction burn
    7. Radiation burn

1.3 Review of the Skin

(Tortora and Derrickson 2011)

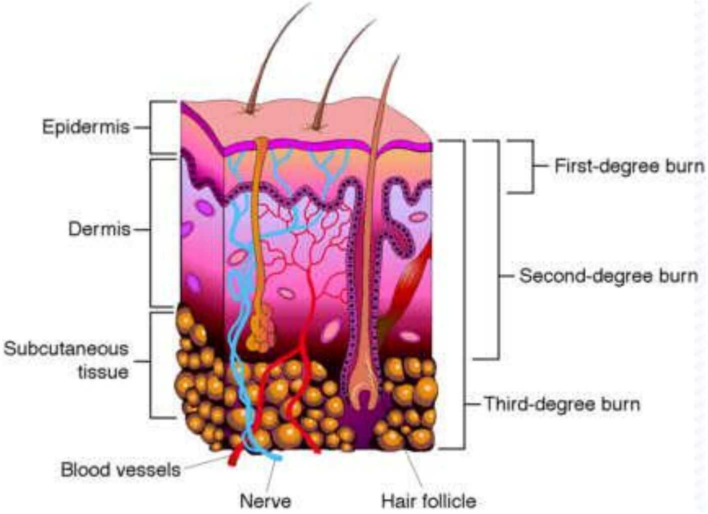


Figure 2. Layers of the skin

(MD 2009)

- Cutaneous membrane which covers the surface of the body
- Largest organ of the body in terms of weight and surface area
- Epidermis
    - Superficial layer
    - Composed of epithelial tissue
    - Avascular
    - Deepest layer (Stratum Basale) contains 'Stem cells'
        - Capable of regeneration
        - New skin cannot regenerate if injury destroys a large portion of this layer
- Dermis
    - Deeper, thicker layer
    - Connective tissue
    - Contains blood vessels, nerves, glands and hair follicles
- Subcutaneous layer
    - Areolar and adipose tissue
    - Storage for fat/ insulation
    - Contains large blood vessels
    - Attaches to underlying facia
        - Connective tissue overlying muscle and bone

1.4 Types of Burns

Degree/Depth	Mechanisms of Injury	Layer of Skin Involved	Appearance	Pain	Scar	Healing Time	Examples
Superficial (1st)	Sun exposure, hot liquids (with low viscosity and short exposure)	Epidermis only	Pink-red, moist, no blisters	Mod-severe	None	3-7 days	
Superficial partial (2a)	Hot liquids, chemical burns (with weak acids/alkali), flash	Superficial (papillary) epidermis	Blister, red moist, intact epidermal appendages, blanches to pressure	Severe	Minimal	1-3 weeks (? Long term pigment changes)	
Deep partial (2b)	Flame, electrical, hot liquid (high viscosity)	Deeper layer (reticular) dermis	Dry, white, non-blanching, loss of all epidermal appendages	Minimal	High risk scarring and contractures	3-6 weeks, with scars	
Deep (3rd)	Flame, electrical, chemical, blast, self-immolation	Full thickness of skin and into the subcutaneous fat or deeper	Leathery, dry, white or red with thrombosed vessels	None in the zone of coagulation but painful at surrounding tissues	Severe risk scarring and contractures	Deal not heal by primary intention, requires skin graft	
4th	Prolonged exposure to flame, electrical, chemical, blast, self-immolation	Extends through skin, subcutaneous fat and into underlying muscle and bone	Black, charred with eschar, dry	None in the zone of coagulation but painful at surrounding tissues	Definite scars and contractures	Requires excision	

Evers, et al 2010, Mayo Clinic 2012,

Table 1 Types of Burns Glassey 2004

1.5 Physiology of Burns

An in depth knowledge of pathophysiology of burns, and their effects both locally and systemically is necessary to ensure effective management of a patient with a burn injury.

1.51 Zones of Injury and Wound Conversion

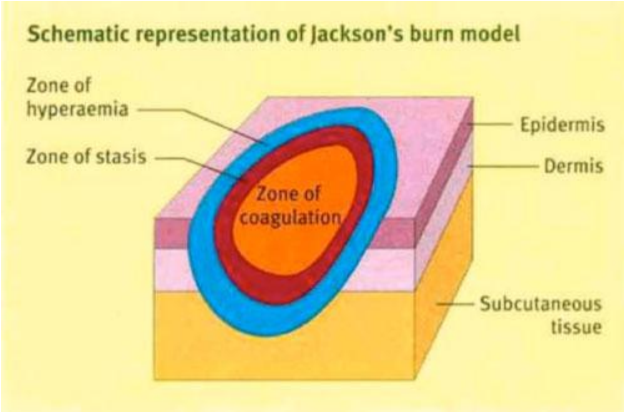


Figure 3 Jackson Burn Model (1947) (www.vicburns.org)

The **local** effect involves **three burn zones**: (Hettiaratchy and Dziewulski 2004)

Zone of Coagulation:

- the point of maximum damage
- Irreversible tissue loss due to coagulation of constituent proteins.

Zone of Stasis:

- Characterised by decreased tissue perfusion
- Potential to rescue the tissue in this zone
- Problems such as prolonged hypotension, infection or oedema can convert this area into one of complete tissue loss

Zone of Hyperaemia:

- The tissue here will invariably recover unless there is severe sepsis or prolonged hypoperfusion.

The depth of the wound develops over time: The burn process peaks at approximately three days. Progression is 3D- zone of coagulation both increases in depth and width (Ever et al 2010).

1.52 Systemic effects

Once the burn covers more than 30% of TBSA, the injury has a systemic effect due to

- Molecular structural alterations
  - Release of toxic metabolites
  - Release of antigen and immunomodulatory agents
    - Histamine, Serotonin, Bradykinin, Nitric oxide, etc.

Causes systemic shock, cardiovascular, respiratory and renal failure, immunosuppression and hypermetabolism. (Evers *et al* 2010)

Cardiovascular Changes

- Myocardial depression
  - Myocardial contractility decreased
- Oedema formation
  - Capillary permeability is increased
  - leads to loss of intravascular proteins and fluids to the interstitial compartment
- Hypovolemia
  - Secondary to oedema and rapid fluid loss from surface of wound
- Peripheral and splanchnic vasoconstriction occurs
  - May cause renal failure

These changes may lead to systemic hypotension and end organ hypoperfusion. (Evers et al, 2010)

Respiratory Changes

Inflammatory mediators cause bronchoconstriction and pulmonary oedema

- severely burnt adults acute respiratory distress syndrome (ARDS) can occur
- Exacerbated in the case of inhalation injury (Evers *et al* 2010)

Metabolic Changes

Hypermetabolism begins approximately five days post burn

- Metabolic state is initially suppressed by the effects of acute shock

- Can persist for up to two years post injury

Inflammatory, hormonal and cytokine milieu cause

- Increased body temperature
- Increased oxygen and glucose consumption
- Increased CO2 and minute ventilation
- Increased heart rate for up to 2 years post burn

(Jeschke et al 2007; Grisbrook et al 2012a; Hurt et al 2000)

This hyper metabolic state leads to energy substrate release from protein and fat stores Protein catabolism

- Loss of lean muscle mass and wasting
- Potentially fatal if structure and function of organs are compromised (Jeschke et al 2007; Hurt et al 2000)

In adults with burns of 25% TBSA, metabolic rate ranges from 118-210% that of predicted values. At 40% TBSA, the resting metabolic rate in a thermoneutral environment is

- 180% at acute admission
- 150% at full healing
- 140% post 6 months
- 120% at 9 months
- 110% at 10 months (Jeschke et al 2007; Herndon and Tomkins 2004)

<u>Gastrointestinal Changes</u>

- Impaired gastrointestinal motility
- Impaired digestion and absorption
- Increased intragastric pH
- Feeding difficulties exacerbate effects of hyper metabolism (Evers *et al* 2010)

<u>Immunological Changes</u>: (Hettiaratchy and Dziewulski 2004)

- Immune deficiency occurs despite the activation of the immune system. High risk of infection, particularly while wounds are open.

1.6 Tissue Healing

1.61 Normal Healing

- Use knowledge of tissue healing to decide when rest is required and when exercise, stretching and strengthening will be beneficial to the patient.
- Timescales are variable according to the size of the burn and surgical intervention. Clinical reasoning is essential when applying the following in practice.

STAGE	TIMESCALE	PROCESS	SIGNS AND SYMPTOMS	TREATMENT
Inflammation	0-5 days	Vasoconstriction followed by vasodilatation and influx of inflammatory mediators and WBCs. Increased capillary permeability. Exudate leaks into tissues. Pus may be produced.	Redness, Heat, Swelling, Pain	Reduce heat and oedema and pain. Prevent infection and disruption of wound. (immobilisation, positioning, splinting)
Proliferation (fibroplasia)	Begins day 3-5. Lasts 2-6 weeks.	Fibroblasts synthesize collagen. Laid down haphazardly. Angiogenesis continues.	Moist red raised tissue over wound	Early: positioning and immobilisation Later: gentle stress (splinting, exercise) Reduce oedema and prevent contracture
Remodelling (maturation)	Begins week 4-6. Lasts up to 2 years.	Synthesis of collagen balanced by degradation. Organisation of collagen fibres along lines of stress.	Wound closure Scar red and raised progresses to flat pale and pliable. Scar tissue tightens.	Optimise function Splinting Positioning Exercise Stretching Strengthening.

Table 2 Tissue healing process following burn injury (Glassey 2004)

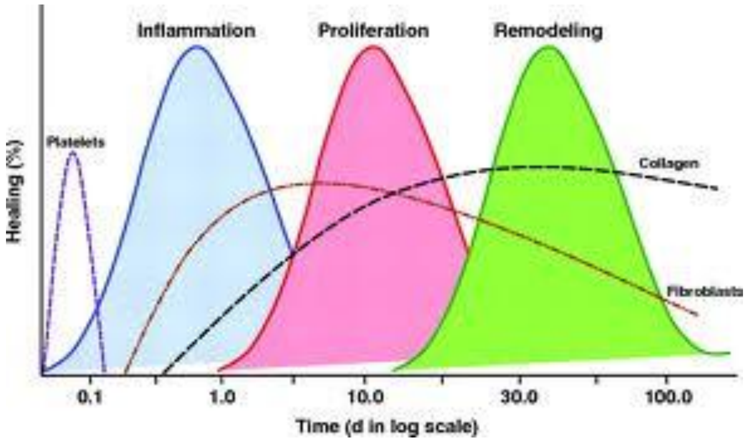


Figure 4 Time scale for the stages of the healing process, showing increasing collagen production over time, and decreasing fibroblast activity. (Glassey 2004)

1.62 Complications of Healing in Burn Patients

1.621 Oedema

Oedema may increase post burn for up to 36 hours

- Increased vascular permeability which occurs during the inflammatory response
- Exacerbated if the burn is severe enough to warrant fluid resuscitation (Weinzweig and Weinzweig 2004; Kamolz et al 2009).

Post severe burn

- The resulting scar (eschar) is inflexible
- Does not allow skin expansion
- Tissue beneath continues to expand as oedema increases
- Rapid increase in compartment pressure
- May result in circulatory compromise/nerve Damage/ necrosis of distal muscles.
- Severe cases require a surgical procedure known as an escharotomy
  - Splits the scar and allows for the expansion of the tissues beneath, relieving pressure (Kamolz et al 2009,Weinzweig and Weinzweig 2004)..

Figure 5. Hand escharotomy (Weinzweig and Weinzweig 2004)

Recognising Vascular Insufficiency: Where oedema and compartment syndrome is causing vascular insufficiency, the following symptoms may be present

- Pain
- Loss of sensation
- Pale white skin on the dorsum of the hand/ distal to eschar
- Loss of peripheral pulses (may also be caused by hypovolaemia or insufficient fluid resuscitation) (Kamolz et al, 2009)

As compartment syndrome requires immediate attention, all health care professionals must remain vigilant.

Oedema and the Hand:

Oedema in the hand results in the position of intrinsic minus (Kamolz et al 2009)

- Wrist flexion
- MCP extension
- PIP/DIP flexion

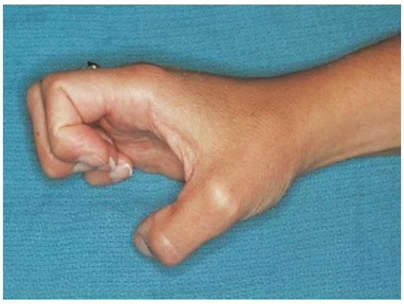


Figure 6 Intrinsic Minus hand position (American Society for Surgery of the hand 2013)

MCP joint extension primary position assumed

- Joint contact areas minimised
- Joint capsules and ligaments lax
- Therefore, in this position, the joint accommodates the maximum amount of intra articular fluid
- Increases tension in finger/wrist flexors , relaxes extensors

  Therefore, PIP/DIP/ Wrist flexion follow (Weinzweig and Weinzweig 2004)
- Joint predisposed to contracture
- May have significant functional implications
- Even after wound healing appears complete, sub-acute and chronic oedema may be caused by scar maturation and contraction: therefore, oedema management is a long term concern.

1.622 Hypertrophic scarring

Hypertrophic scars are a common complication of burn injuries. A healing wound requires a balance of several opposing reactions

- Degradation of necrotic tissue/proliferation of new cells
- Building up/ breaking down of collagen
- Creating/controlling of new blood supplies (Linares et al 1996).

Disequilibrium of any of these processes may result in abnormal scarring. There is a high risk of a scar becoming hypertrophic if early wound closure is not achieved. Estimates for optimal closure time vary from 10 days (ANZBA 2007) to 21 days (Procter 2010). Hypertrophic scarring is accompanied by:

Figure 7. Hypertrophic scar on dorsum of hand (Procter 2010)

- Exaggerated angiogenesis with high blood flow
- Increased deposition of collagen
- High rates of contraction
- Pruritus (Itch)
- Dryness
- Lack of pliability. (Procter 2010).
- The orientation of new collagen bundles remain haphazard
- haphazard structure persists for several months post Injury.
- Some degree of chronic inflammation may also persist. (Linares et al 1996).

Identifying Hypertrophic Scarring

- Shapes and sizes depend on location on the body and nature of injury
- Edges are raised and end abruptly
- Initially may be red or pink in colour
    - Blanch over time, as the scar matures
    - Never returns to original colour/texture
- May exceed the limits of the original injury (Keloid scars).

(Linares et al 1996; Procter 2010)

1.7 Burn Associated Pain

"The quality of outcome must be worth the pain of survival"

~Prof FM Wood, James Laing Memorial Essay, 1995

- 84% of major burn patients suffer "severe or excruciating pain"
- 100% suffer daily pain
- 92% are woken at night with pain (ANZBA 2007)

1.71 Types of Pain in Burns: (Summer et al 2007; Richardson and Mustard 2009)

Procedural pain: (Primary mechanical hyperalgesia): intense burning and stinging that continues to a lesser degree, but may be accompanied by intermittent sharp pain for minutes or hours following dressing changes or physiotherapy/occupational therapy. Throbbing, excruciating pain may be associated with positioning of burned extremities (i.e. positioned below the level of the heart); this is thought to be related to pressure associated with inflamed, oedematous tissue. Procedural pain is the most intense and most undertreated pain associated with burn injuries.

Procedural pain and associated pain anxiety**:** research indicates pain-anxiety increases over time in burn injured patients. Strong correlations have been established between pain, physiological distress and physical and psychological outcomes in both adults and children.

Background pain**:** patients with high anxiety have increased levels of background pain. There is a wide variability in the pain intensity following injury. Background pain is characterised by prolonged duration, relatively constant mild-moderate intensity pain. The pain has been described as continuous burning or throbbing, present even when the patient is relatively immobile. This pain is best treated with regularly scheduled analgesics.

Breakthrough pain: transient worsening of pain frequently associated with movement. Patients also report spontaneous pain that may be related to changing mechanisms of pain, over time or inadequate analgesia. The pain can be described as stinging, shooting, pricking or pounding. Pain following movement can be associated with primary mechanical hyperalgesia, but most care providers for those with burns consider pain with movement to be breakthrough pain. Breakthrough pain can be much worse following periods of immobility, particularly if skin over joints is affected.

For optimal analgesia, it is recommended that patients are assessed for each type of pain separately and repeatedly throughout the course of the recovery.

Figure 8. Factors influencing the patient's perception of pain from a burn wound.
(Richardson and Mustard 2009)

1.72 Pain Mechanisms

(Richardson and Mustard 2009)

The pain mechanisms associated with the inflammation process post burn are:

- Primary hyperalgesia
- Secondary hyperalgesia
- Neuropathic pain
- Chronic pain/Central Sensitisation

Other factors to consider in pain are:

1.73 Pain intensity: As the inflammation recedes, the quality of the pain may change. The reporting of pain intensity varies widely and is reported highest in areas of upper/mid-dermal skin loss, such as areas of skin donation and decreases with wound closure. Infection may result in increased pain again following revival of the inflammatory process. Growth of new tissue is associated with paraesthesia and local discomfort. The healed areas show enhanced mechanical hyperalgesia following subsequent injury.

1.74 Anxiety and pain experience: result in increased pain perception. The pain experience will alter according with the burn treatment. Surgery/debridement/excision of the burn will alter the depth of the burn injury. Covering the burn with grafts or synthetic dressings typically reduce pain, with the harvest site often being more painful than the burn injury itself. Poor pain management during therapeutic procedures is associated with poor compliance with treatment and post-traumatic stress disorder. It then increases anxiety and worsens the pain experience in subsequent treatment.

Section 2: Burn Assessment

A burn is a unique injury to the individual patient. The assessment and management of an initial burn by the multidisciplinary team is crucial to minimise long term injuries and enhance optimal functioning.

For the purpose of this handbook the information detailed throughout the assessment of the burn patient is a synopsis of the following papers:

ANZBA 2007; British Burn Association 2005; Eisenmann-Klein 2010; Hettiaratchy et al 2004; Settle 1986; Siemionow and Eisenmann-Klein 2010

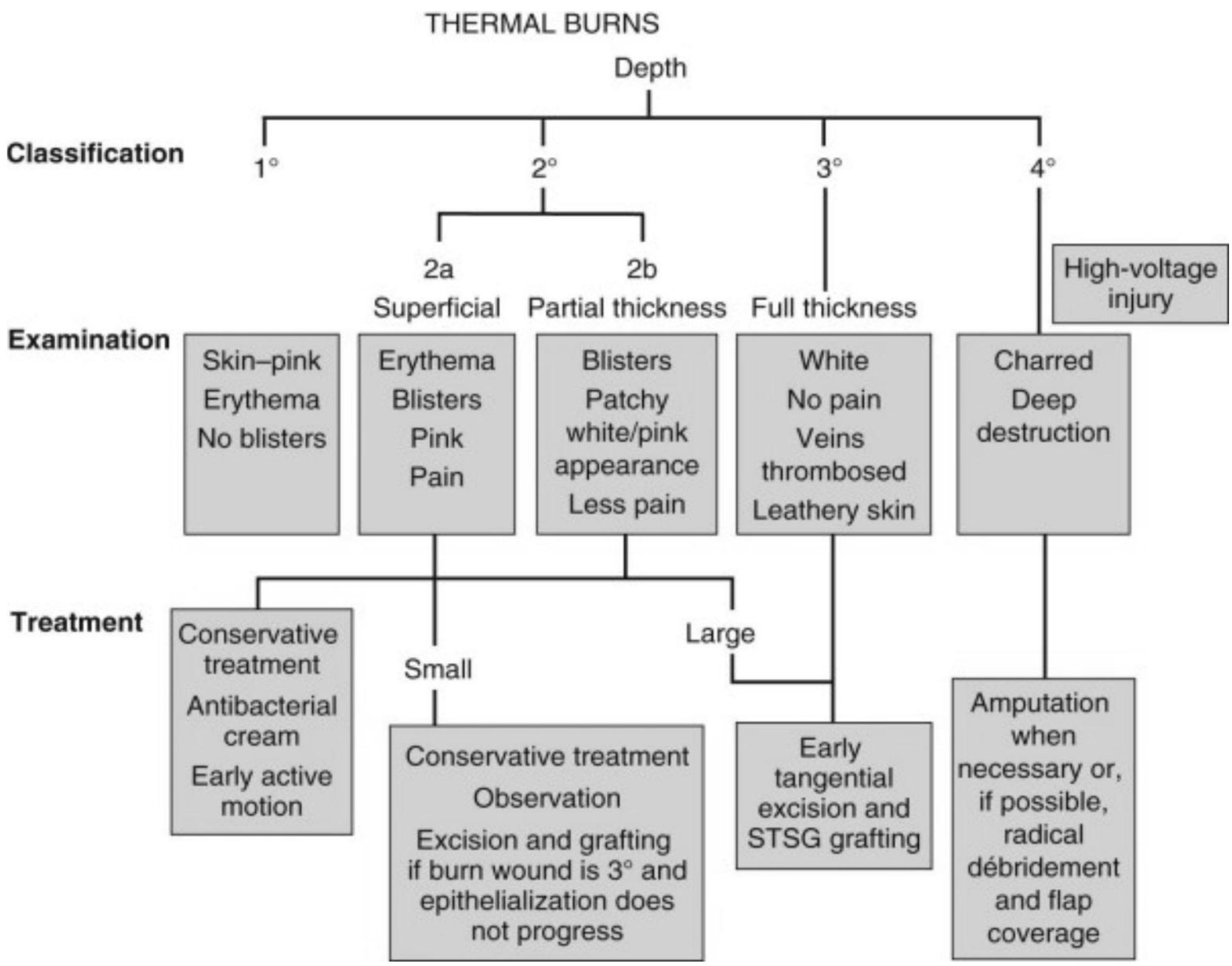


Figure 9. Flow chart illustrating the assessment and management of the burn

(Germann et al 1999)

Physiotherapy Assessment of the Burn Patient

The physiotherapist must be aware of the importance of an early and adequate assessment of Burn patients for optimal functional and cosmetic outcomes to minimise the impact of the trauma long term. They must have a concise knowledge of the assessment procedure through from Accident and Emergency to the ward, onto the rehabilitation setting and out in the community. The following information is gathered through assessment, and a treatment plan is formulated, constantly reassessed and revised.

(ANZBA 2007; Hettiaratchy and Papini 2004)

Physiotherapy aims

1. Prevent respiratory complications
2. Control Oedema
3. Maintain Joint ROM
4. Maintain Strength
5. Prevent Excessive Scarring

Patients are at high risk due to:

1. Injury factors - Inhalation injury; burn area - systemic inflammatory reaction syndrome involving the lungs; depth of burn and scarring

2. Patient factors - Reduced ambulation and mobility; increased bed rest; increased Pain; pre-existing co-morbidities

3. Iatrogenic factors – Skin reconstruction surgery; invasive monitoring and procedures, management in critical care

2.1 Database/Subjective Assessment

The following pieces of information should be included in the physiotherapists' database.

2.11 Presenting Complaint

Inhalation injury

There should be a high index of suspicion if the patient was injured in an enclosed space and / or had a reduced level of consciousness – aggressive respiratory treatment to commence immediately (ANZBA 2007; British Burn Association 2005; Eisenmann-Klein 2010)

Total Body Surface Area (TBSA)

- The rule of nine or the Lund and Brower chart are used to assess the TBSA
  - The Lund and Brower Charts are considered to be more accurate than rule of nines, but both are commonly used.

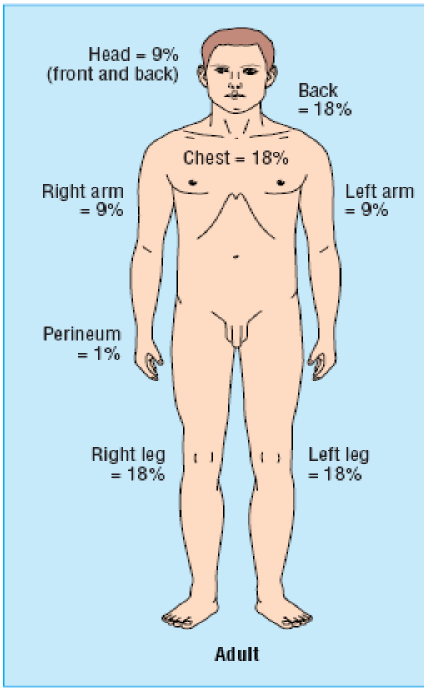


Figure 10a. Rule of Nine Assessment Chart: Hettiaratchy and Papini (2004)

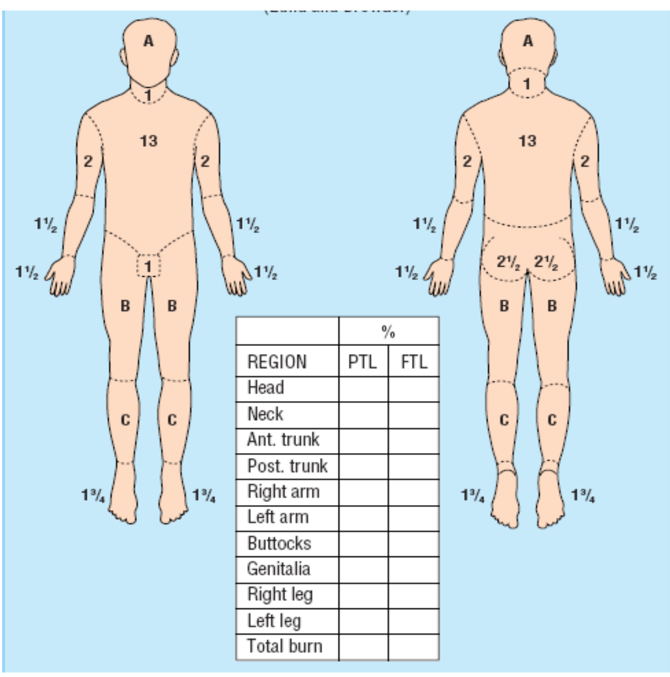


Figure 10b. Hettiaratchy and Papini (2004)

Table 3: An adjustment for age: Hettiaratchy and Papini (2004)

Area	Age 0	1 year	5years	10 years	15 years	Adult
A= (½ of head) %	9 ½	8 ½	6 ½	5 ½	4 ½	3 ½
B= (½ of one thigh) %	2 ¾	3 ¼	4	4 ½	4 ½	4 ¾
C= (½ of one lower leg) %	2 ½	2 ½	2 ¾	3	3 ¼	

- Measure burn wound areas by mapping wound – 1% TBSA ≅ patient's hand (palm and fingers included)
- Note: when calculating burn size area, oedema should not be included.
- A burn of > 20 – 25% TBSA creates a global or systemic inflammatory reaction affecting all body organs and indicates a significant risk for the respiratory system

<u>Burn Type and Depth</u>

- It is important to monitor extent of tissue destruction as it alters for at least 48 hours post burn injury
    - Jacksons' burn wound model.
- It is rare that a burn will present with a single depth.
- Likely to change depending on the early management e.g. appropriate first aid and other patient factors. (ANZBA 2007; British Burn Association 2005; Eisenmann-Klein 2010)

<u>Burn Site and Impact</u>

- Develop awareness of the implication of burn to special areas of the body. the following require specialised treatment
    - Hands
    - Face
    - Perineum
    - Joints

This is in consideration of the complexity of the post burn reconstruction and potential functional impact of inappropriate management of these important body areas.

2.12 History of Presenting Complaint

- History of the incident with specific attention paid to the mechanism of injury.
- First aid – was adequate first aid given? - If not, suspect deeper burn injury
- Falls – was there any indication that the patient fell? From what height? – possible head injury, sprains or fractures
- Electrical injury – voltage involved? Parts of body in contact with earth? – suspect nerve and deep muscle injury with high voltage current
- Explosions – falls, high velocity injuries, possible tympanic membrane injury – loss of hearing and difficulty communicating
- Passage to hospital and time to admission

ANZBA 2007; British Burn Association 2005; Eisenmann-Klein 2010;

2.13 Medical and Surgical History

- Any surgical or medical management
    - Pain medication
    - Debridement
    - Escharectomy
    - Flaps/grafts
    - Any particular MDT instructions to be followed

ANZBA 2007; British Burn Association 2005; Hettiaratchy et al 2004

2.14 Past Medical/ Drug History

2.15 Social History ANZBA 2007; British Burn Association 2005; Eisenmann-Klein 2010

- Basic ADL e.g., dressing, bathing, eating and Instrumental ADL e.g., shopping, driving, home maintenance
- Past physical function e.g., mobility, climbing stairs, reaching, lifting
- Past physical fitness e.g., strength, flexibility, endurance, balance
- Social support and home Situation
- Occupation
- Particularly important for hand burns

2.16 Psychosocial/ Yellow Flags

- Self-image
- Coping style
- Mental health
- Emotional behaviour

ANZBA 2007; British Burn Association 2005; Hettiaratchy et al 2004

2.17 Considerations for the Assessment of Hand Burns

The area of the hand that is injured has a huge impact on recovery. A burn on the hand can have detrimental effects for ADLs and functioning. Dependant on the area and depth of the burn, it may lead to significant deformity.

Assessment

- Evaluation and classification of the size and depth of the burn of the hand
- Post burn Hand Deformities
    - First web adduction contractures
    - Web space contractures
    - Dorsal skin contractures
    - Digital flexion contracture
    - Boutonniere deformity
    - Dorsal skin deficiency
    - Digital loss secondary to ischemia
    - Median and ulnar nerve compression
    - Syndrome
- Conservative or operative treatment
    - Surgical management—removal of eschar, transplantation of skin grafts, flap
- Early postoperative physical therapy
- Functional rehabilitation
- Secondary and tertiary corrections if necessary

2.2 Objective Assessment

2.21 Pain Intensity Assessment

- Observational behavioural pain assessment scales should be used to Measure pain in children aged 0 to 4 years e.g. The FLACC scale
- Faces pain rating scale can be used in children aged 5 years and older. E.g. The Wong-Baker FACES pain rating scale
- VAS can be used in children aged 12 years and older and adults.

2.22 Inhalation Assessment

Physical signs to observe:

- Hoarse vocal quality
- Singed facial / nasal hair
- Oedema
- Erythema *(Superficial reddening of the skin, usually in patches, as a result of injury or irritation causing dilatation of the blood capillaries)*
- Soot stained sputum
- Stridor
- Inspiratory and end expiratory crackles on auscultation
- Chest x-ray changes (ANZBA 2007; British Burn Association 2005)

2.23 Oedema Assessment

Overview

An acute burn injury creates inflammation and swelling. After wound healing is complete, scar tissue maturation and contraction may lead to sub-acute and chronic states of oedema formation. With time, oedema fluid changes in its composition and creates greater stiffness and resistance to movement within the tissues. This is particularly notable when surgical reconstruction is required and if the burn is circumferential around limbs or other structures. See table 4 for clinical stages of oedema. (ANZBA 2007; British Burn Association 2005; Eisenmann-Klein 2010)

Stage of Oedema	**Appearance of Oedema**
Stage 1	Soft, may pit on pressure
Stage 2	Firm, rubbery, non-pitting
Stage 3	Hard, fibrosed

Table 4: Clinical stages and Appearance of Oedema

2.34 Mobility Assessment

The assessment and treatment of mobility can be separated into two aspects - the limbs & trunk, and general functional mobility (e.g. transferring and ambulation). A physiotherapist must also consider factors such as increased bed rest, increased pain and pre-existing co-morbidities. (ANZBA 2007; Hettiaratchy et al 2004; Settle 1986; Siemionow and Eisenmann-Klein 2010)

2.341 Limb and Trunk

Assessment of limbs and trunk should include joint ROM and strength. Limiting factors may include pain, muscle length, trans-articular burns, scar contracture and the individual specificity of the burn.

2.342 General Functional Mobility

Assessment of general mobility is two-fold, prevention of complications associated with prolonged bed rest and the restoration of function & independence. All functional transfers, gait, endurance and balance should be assessed once the patient is medically stable.
Factors to consideration when assessing mobility:

- Posture
- Demands of vocational roles and ADLs
- Cardiovascular response to mobilisation
- Neurological status
- Pain
- Concomitant injuries/weight-bearing status

2.4 Burn Outcome Measures

Limitless amount of outcome measures are used to assess burn injury with no unanimity about what domains to measure or whether a range of measures are required to capture the full extent of the burn, from the patient's perspective to the clinician. Lack of consistency in the use of instruments has resulted in a lack of clarity about the selection of instruments or 'how to measure' (Brusselaers et al 2010; Wasiak et al 2011).

Burns Specific OCMs:

1. Burn Specific Health Scale (BSHS) – Revised (BSHS-R) – Brief (BSHS-B) - Abbreviated (BSHS-A)

Burn Specific Health Scale (BSHS)

Use: BSHS is consistently and widely used within the area of burn to examine the physical and psychosocial functioning of burn patients and their quality of life (QOL) (Yoder et al 2010)

Reliability: While the BSHS is a valid and reliable tool used in the burn population, it is critical to determine the purpose of using any one specific version. The BSHS –B has good reliability and validity when compared with the BSHS –A and revised versions (Yoder et al 2010).

Validity: Many studies have validate this scale while also trying to revise, abbreviated and create brief versions of it to make it easier to use (Yoder et al 2010).

Sensitivity: Limitations of this scale surrounds the clarity of some components, interpretation of the answers by patients and the specific use of versions.

When the BSHS – B is used in comparison with the SF -36 health questionnaire, the BSHS – B was seen to provide more useful information with fear avoidance and post-traumatic stress disorder in relation to returning to work (McMahon 2008).

See ANZBA for a full list of outcome measures. Comply with local policy according to evidence based practice. Many generic outcome measures (e.g. DASH) may be used with burn patients, depending on site and extent of the burn.

Section 3: Management of Burn Pain

3.1 Pharmacological Pain Management: (Richardson and Mustard 2009)

- During the first 48 hours
  - Decreased organ blood supply alters the clearance of drugs
  - The body then enters a hyper metabolic state,
    - Associated with increased clearance of analgesia.
  - Variations in levels of acute phase plasma and total body water volume further impact upon effectiveness an analgesia.
  - Regular and repeated pain assessments are used to monitor the effectiveness of analgesia.

Thus there is no standard treatment of burns patients, each requires individual assessment.

Opioids: the cornerstone of pain management in burns, and are available in a variety of potencies, methods of administration and duration of action. Opioids used to effectively manage background pain, with well-timed and effective doses of opioids used separately to manage procedural pain

Positive Effects	Side Effects	Examples of Opioids
Pain relief Increased comfort Morphine related to reduced Post-traumatic stress disorder	Respiratory distress Itch Nausea and vomiting Opioid tolerance – requiring increasing doses Opioid induced hyperalgesia (OIH) – increased sensitivity, throughout the body following opioid exposure Provide poor defence against central sensitisation Physical dependence – common in long term use	Morphine Oxycodone Fentanyl: potent, rapid onset, short acting opioid. Used for procedural pain management. Remifentaril: ultra-short acting opiate. Alfentaril: short acting, used for post-procedural analgesia.

Table 5: side effects of opioids

Simple analgesics**:** paracetamol can be used in conjunction with opioids, to give a synergistic effect comparable to a higher opioid dose. Paracetamol is an effective anti-pyretic and has few contra-indications.

NSAIDS: synergistic with opioids and can reduce opioid dose and thus reduce side-effects. Not used in wide spread burns due to already increased risk of renal failure and peptic ulceration. There is potential to increase bleeding in large burns also, due to the anti-platelet effect.

Other medications: see **Richardson and Mustard 2009**

Possible side effects of analgesics:

- Drowsiness
- Adverse reaction
- Nausea and increased risk of aspiration
- Impaired memory and communication
- Postural hypotension, and fainting (ANZBA 2007)

3.2 Non-Pharmacological Management of Pain

The following is a synthesis of information form the following articles: Summer et al (2007), Richardson and Mustard (2009), ANZBA (2007) and de Jong et al (2007)

Overall, the levels of evidence to support the use of alternative therapies for pain relief are of poor quality. However, no negative side effects were reported in the literature reviews and these therapies are all used in conjunction with pharmacological management to optimize pain relief for the individual.

3.21 Psychological techniques: beneficial for reducing anxiety and providing patients with coping methods for pain levels and durations. These include relaxation, distraction and cognitive behavioural therapy (CBT). CBT is beneficial in the management of complex pain problems and can reduce fear and anxiety associated with activities or environments.

3.22 Hypnosis: a state of “increased suggestibility, attention and relaxation”. In the burn patient hypnosis is used in the management of procedural pain and anxiety. The use of hypnosis clinically is increasing but its usefulness is dependent on the individual’s hypnotic susceptibility, high baseline pain and the skill of the practitioner. The current best available evidence for management of procedural pain was found for active hypnosis, rapid induction analgesia and distraction relaxation.

3.23 Virtual Reality: immersing the patient in a virtual world has shown some effect on procedural pain control and is better than hand-held gaming devices. However, the equipment is costly and bulky and not always suitable for paediatric intervention. A paediatric intervention, using hand-held game devices which provide augmented reality was trialled among 3-14 year olds. This has shown significantly lower pain scores than standard distraction and relaxation when undergoing dressing changes (Mott et al 2008).

3.24 Sleep Normalisation: disrupted sleep occurs in up to 50% of burn patients and links have been established between poor sleep quality and pain severity, as well as pain and prolonged experiences of sleep disturbance. Normalisation of the 24hour day, with a bedtime routine, within the limits of the hospital environment is aimed for to promote sleep, with the use of analgesics and night sedation.

3.25 Music therapy: this is thought to target pain via the gate control theory. This suggests that music serves as a distraction from noxious stimuli. Also, the anxiety related to the rehabilitation of burns can increase the activation of the sympathetic nervous system. Music uses all three cognitive strategies employed in pain and anxiety management (imagery – envisioning events that are inconsistent with pain, self-statements and attention-diversion devices to direct attention away from the pain ad redirects it to another event) (Ferusson and Voll 2004; Presner et al 2001).

A systematic review of music therapy among pregnant women, medical-surgical patients and critical care patients showed statistically significant reductions in pain scores. Of the seventeen studies reviewed by Cole and LoBiondo-Wood (2012), 13 studies demonstrated the positive effects of music on pain. Other positive findings of the studies included reduced anxiety, muscle tension, blood pressure and heart rate. A burn specific study included showed reduced pain levels during and after the debridement, reduced anxiety and decreased muscle tension during and after dressing changes.

The Cochrane Review of music as an adjunct to pain relief concluded that "music and other non-pharmacological therapies could have a synergistic effect to produce clinically important benefits on pain intensity or analgesic requirements" and thus requires further study. This is based on the studies indicating that music resulted in reduced pain intensity and reduced opioid requirements. The reported changes in both of these outcomes were small however, and their clinical importance is unclear (Cepeda *et al* 2006).

3.26 Paediatric Burn Pain (Richardson and Mustard 2009)

- children 0-4 years represent approx. 20% all hospitalised burn patients
- In preschool aged children the half-life of opioids (morphine and alfentanyl) are 50% those in adults. Higher dosage required.
- Risk of accidental overdose due to difficulties with pain evaluation resulting in overestimation of child's pain
- Childs environment has huge effect on pain perception. Parents' presence and aid during dressing change can have beneficial for procedural pain and reducing anxiety.

3.3 Considerations Pre Physiotherapy Treatment

- Pain relief is key. Timing physiotherapy to correspond with analgesia is essential for the patient, particularly to avoid the pain-anxiety avoided.
- Knowledge of pain medications, short-acting pain relief may be required in addition to long-acting background pain relief prior to physiotherapy. Also, the side-effects possible due to the medications, and vigilance for signs of these.
- Daily assessment of therapy input and pain management to ensure on-going management of pain. (ANZBA 2007)

Section 4: Reconstruction Post Burn Injury

The impact of reconstructive surgery post burn injury has a major impact on a patient. As an allied health professional, we must work as part of an MDT in order to ensure successful surgery while at the same time ensuring long term health and function. Timely burn wound excision and skin grafting form the cornerstone for acute burn surgical management (Klein 2010).Surgery for burned patients is not normally indicated until 48 hours after injury, when the depth of the burn has been established. The only exception is when necrotic tissue is evident then early excision may be required. A plastic surgeon must reconstruct the injured body part in a way that is extensible, sensate and cosmetically acceptable (Glassey 2004). In addition to this, they must rebuild or replace muscles, tendons, joints and nerves to ensure they are appropriately intact.

4.1 Aims

1. Achieve would closure
2. Prevent infection
3. Re-establish the function and properties of an intact skin
4. Reduce the effect of burn scars causing joint contractures
5. Reduce the extent of a cosmetically unacceptable scar

(Glassey 2004; BBA Standard 6 2005)

4.2 Choosing the Correct Method of Reconstruction

The simplest management involves conservative wound care and dressings, while the most complex is free-flap reconstruction. When deciding on the most appropriate intervention, a surgeon must consider the extent of the missing tissue and the structures effected (Glassey 2004). Generally, a superficial partial thickness burn will heal with conservative treatment (secondary intention) in 10 days to 3 weeks, unless infection occurs. Primary intention occurs if a wound is of such size that it can be closed directly without producing undue tension at the wound site. Delayed primary closure occurs once a suspected infection has been cleared. Deep partial and full thickness burns both require surgical intervention. Surgery normally takes place within the first 5 days post injury to prevent infection which could extend the depth of the tissue loss (Glassey 2004).

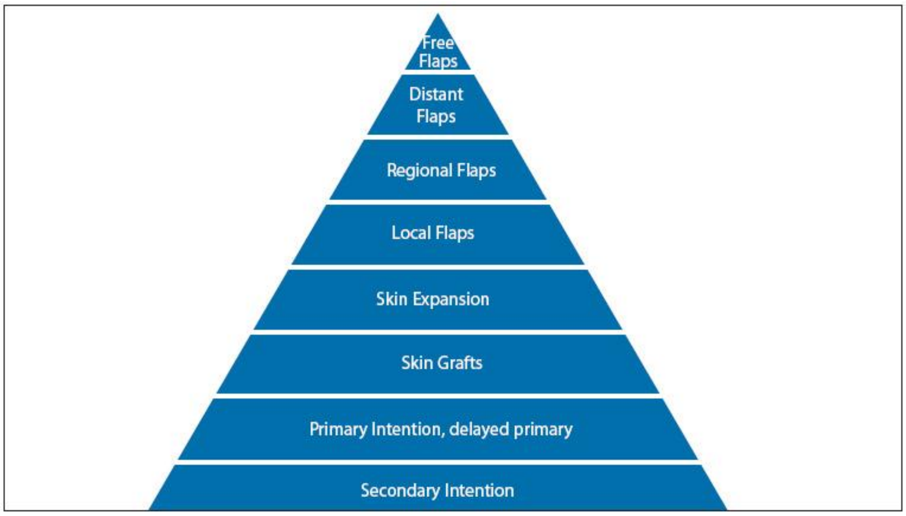


Figure11. The reconstructive ladder, procedures ranging from simplest to most complex.
(Ataturk University School of Medicine 2009)

4.3 Skin Grafts

"A **skin graft** is the transportation of skin from one area of the body to another."

(Glassey 2004)

A graft is an area of skin that is separated from its own blood supply and requires a highly vascular recipient bed in order for it to be successful. Prior to grafting, the process of wound debridement must take place. Wound debridement involves removing necrotic tissue, foreign debris, and reducing the bacterial load on the wound surface (Cardinal *et al* 2009).This is believed to encourage better healing. The following are the methods available for grafting onto a debrided wound to obtain closure:

- Autograft ('split skin graft') (own skin)
- Allograft (donor skin)
- Heterograft or xenografts (animal skin)
- Cultured skin
- Artificial skin (Glassey 2004)

4.31 Meshed vs. Sheet Grafts

Sheet grafts are those which are not altered once they have been taken from the donor site.

Meshed grafts are those which are passed through a machine that places fenestrations (small holes) in the graft. Meshed grafts have advantages over sheet grafts of 1) allowing the leakage of serum and blood which prevents haematomas and seromas and 2) they can be expanded to cover a larger surface area.

(Klein 2010)

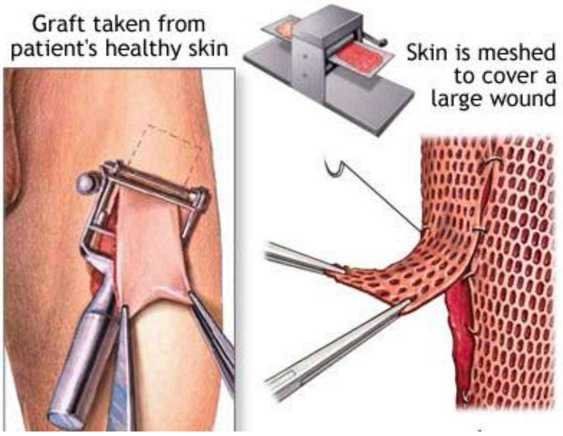


Figure12. Diagrams illustrating the process of mesh graft procedure (www.beltina .org)

4.311 Criteria to be met Pre- Grafting

- Diagnosis of DEEP tissue loss
- Patient is systemically fit for surgery
- Patient has no coagulation abnormalities
- Sufficient donor sites available
- Would clear of streptococcus

(Glassey 2004)

4.312 The Donor Site

The thigh is the most common donor site for split thickness skin grafts (STSG). A split thickness graft involves a portion of the thickness of the dermis while a full thickness skin graft (FTSG) involves the entire thickness of the dermis (Klein 2010). The most common site for full thickness skin grafts is the groin. Cosmetic areas such as the face should be avoided for graft donation.

The donor site should just be left with a superficial or a superficial partial thickness wound which will heal in 10-14 days and may be reused if necessary. Often, the donor site can be more painful than the recipient due to exposure of nerve endings (Glassey 2004).

4.313 Skin Substitutes

> "**Skin Substitutes** are defined as a heterogeneous group of wound cover materials that aid in wound closure and replace the functions of the skin either temporarily or permanently"
>
> (Halim *et al* 2010)

Conventionally, STSG and FTSG have been found to be the best option for burn wound coverage (Halim *et al* 2010). However, in cases of extensive burn injury, the supply of autografts is limited by additional wound or scarring at donor sites. For this reason, skin substitutes will be required. Skin substitutes require higher cost, expertise and experience than autografts. However, they also offer numerous advantages in the form of rapid wound coverage requiring a less vascularised wound bed, an increase in the dermal component of a healed wound, reduced inhibitory factors of wound healing, reduced inflammatory response and reduced scarring (Halim *et al* 2010).

Currently, there are various skin substitutes on the market but scientists and engineers are working towards producing the optimal skin substitute. As a general rule, skin substitutes are classified as either temporary or permanent and synthetic or biological. A very clear and concise overview of the different skin substitutes available for burn injuries is provided in Halim *et al* (2010).

4.314 The Recipient Site

The graft should take within 5 days and will provide a permanent covering of the injury. A graft should always be placed over bleeding, healthy tissue to ensure it is vascularised for survival (Glassey 2004).

Post-operatively the graft site is dressed to ensure pressure is created over the graft to limit haematoma formation. The body part is immobilised in an anti- deformity position at first in order to prevent shearing forces that could disrupt the graft (Edgar and Brereton 2004). Some very mobile body parts, such as the hand, may require splinting to ensure joint immobility.

4.315 Process of Graft 'Take'

- Serum Inhibition (24-48hrs): fibrin layer formation and diffusion of fluid from the wound bed

- Inoscultation (day 3): capillary budding from the wound bed up into the base of the graft
- Capillary in-growth and remodelling (Glassey 2004)

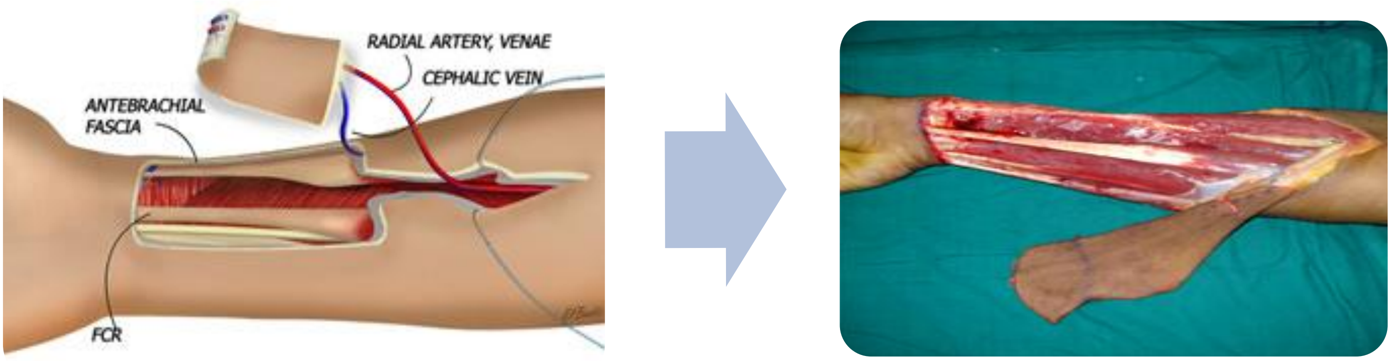
<u>4.316 Reasons for Graft Failure</u>

- Inadequate blood supply to wound bed
- Graft movement
- Collection of fluid beneath graft (e.g. haematoma)
- Infection (e.g. streptococcus)
- The grafts properties (e.g. vascularity of donor site) (Glassey 2004)

<u>4.4 Skin Flaps</u>

The difference between a skin graft and a skin flap is that "a **skin flap** contains its <u>own vasculature</u> and therefore can be used to take over a wound bed that is <u>avascular</u>". A skin graft does not have this ability (Glassey 2004). When speaking about grafts and flaps in the research, skin flaps is often incorporated into the term 'skin grafts'.

Fig 13: skin flaps



(MicroSurgeon, 2012)

Tissues which a skin graft will not take over include and which a skin flap will include:

- Bone without periosteum
- Tendon without paratenon
- Cartilage without perichondrium (Glassey 2004)

4.41 Categorisation of Skin Flaps

Based on three factors:

1. Vascularity
2. Anatomical composition
3. Method of relocation (Glassey 2004)

4.411 Vascularity

Flaps can be classified as either random pattern flaps or axial flaps depending on their vascularity. Random pattern flaps are not raised on any particular major blood vessel, but instead are raised on smaller branches of these blood vessels known as the subdermal plexus. These flaps are limited in size to ensure distal parts do not become ischemic (Glassey 2004). Examples of these flaps include Z-plasty, V-Y advancement flap, rotation flap and transposition flap. Axial flaps, on the other hand, are raised upon a specific blood vessel which allows them to be lifted on a narrow pedicle and ensures greater perfusion for survival (Glassey 2004).

4.412 Flap anatomical Composition

Flaps are also classified depending on their composition, i.e. which layers of the skin they contain. The composition is often clear from the name of the flap.

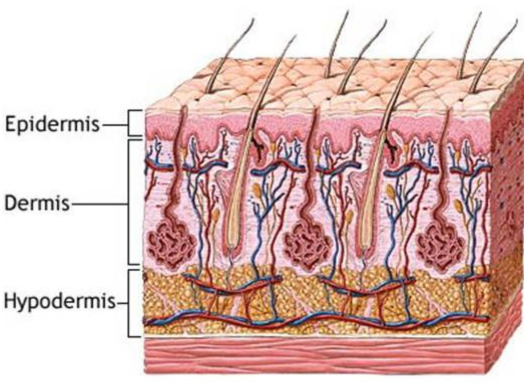


Figure 14 Illustration of the layers of the skin (About.com 2013)

- Skin Flap- epidermis, dermis and superficial fascia
- Fasciocutaneous Flap- epidermis, dermis and both superficial and deep fascia
- Muscle Flap-muscle belly without overlying structures
- Myocutaneous Flap-muscle belly with the overlying skin
- Osseous Flap- bone
- Osseomyocutaneous Flap-bone, muscle, skin
- Composite Flap- Contains a no. Of different tissues such as skin, fascia, muscle and bone. (Glassey 2004)

4.413 Relocation of Flaps

The third way in which flaps are classified is by their method of relocation. Flaps are defined as either 'local' or 'distant' depending on the distance between the donor and recipient sites (Glassey 2004).

Local Flaps: *Rotation or transpositional flaps* are tissue that is lifted and manipulated to cover the local defect, maintaining their connection with the body. Therefore, they are never fully excised. *Advancement flaps* are those in which the tissue is moved directly forward to cover the defect, e.g. V-Y flaps used to cover finger-tip injuries

(Glassey 2004).

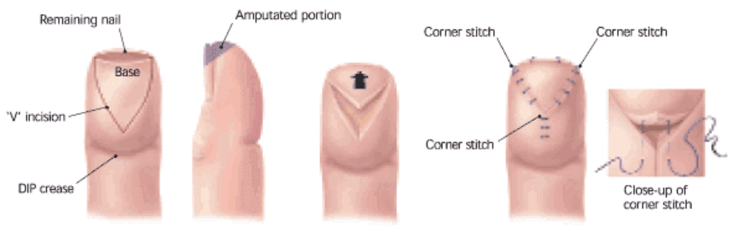


Figure15. V-Y flap for finger-tip injury

(American Academy of Family Physicians 2013)

Distant Flaps: *Pedicled flaps* are those which are transferred to another area of the body but the vascular attachment is always maintained and so the distance it can travel depends on the length of the pedicle. *Free flaps* are those in which the tissue is completely separated from the body and transferred to another area and the vascular supply is re-established by anastomising the blood vessels (Glassey 2004).

4.42 Monitoring Flaps

Flap survival is dependent on perfusion and so any interruption to its blood supply will cause its failure. Flaps should be monitored every half an hour for 36 hours checking for flap colour, temperature, texture and any signs of blanching. Patients post skin reconstruction should be kept in a room at higher temperature than normal in order to encourage vasodilatation. Flap survival will be compromised if any of the following are present; hypothermia, variations in blood pressure, tension, compression, haematoma, infection, nicotine, dehydration and caffeine (Glassey 2004).

As a physiotherapist treating a patient post skin reconstruction surgery, we need to be aware of these insufficiencies we could possibly cause and therefore prevent them.

Section 5: Rehabilitation Post Burn Injury

Significant improvements in the medical and surgical management of burns has occurred in the last century. Increased survival rates mean that focus is turning to achieving optimal functional outcomes.

- Burn survivors often suffer from
  - permanent scarring, reduced range of motion, weakness, and impaired functional capacity
  - psychological and social problems, which significantly affect their ability to resume their normal activities post discharge
- Rehabilitation requires a prolonged, dedicated and multidisciplinary effort to optimise patient outcomes, as inpatients and outpatients.

(Schneider et al 2012; Disseldorp et al 2007; Esselman, 2007)

The aims of the multidisciplinary rehabilitation of a burn include:

- Prevention of additional/deeper injuries
- Rapid wound closure
- Preservation of active and passive ROM
- Prevention of infection
- Prevention of loss of functional structures
- Early functional rehabilitation (Kamolz et al 2009)

The physiotherapist may only have a role in achieving some of these goals.

- Above all **cause no harm**.

Early initiation of rehabilitation is essential to maximise functional outcomes for the patient

- The pain and psychological distress of a burn has a massive impact on compliance
  - An empathetic, encouraging and understanding approach is necessary
- The urgency and importance of beginning early rehabilitation should be communicated in a clear but gentle manner (Procter 2010).

5.1 Role of the Physiotherapist in the Rehabilitation of the Acute Burn Patient

For the purpose of clarity, the following section has been divided into acute, sub acute and chronic rehabilitation. However, rehabilitation is a continuum, and significant crossover may occur. All of the following concepts apply to burns on any part of the body, with specialised treatment addressed for the hand where necessary.

Depending on the size and the severity of the injury this stage may last from a few days to a few months (Procter 2010)

Patient

- Acute phase of inflammation
- Pain
- Oedema increasing for up to 36 hours post injury
- Hypermetabolic response, peaking at five days post injury
- Early synthesis and remodelling of collagen

Aims

- Reduce risk of complications
    - Reduce oedema, particularly where it poses a risk for
        - impinging on peripheral circulation or airways
        - Predisposition to contractures
- Prevent deformities/loss of range
- Protect/promote healing

Common treatment techniques

- Immobilisation
    - Bed rest
    - Splinting
- Positioning

5.11 Immobilisation

5.111 Rationale for Immobilisation

Acute Stage	• Prevent deformities • Maintenance of range of motion • Promote Healing • Protection	(Ashe 2001; Kamolz 2009)
Sub-acute Stage	• Maintenance of range of motion • Regain range of motion	(Kwan 2002; Boscheinen-Morrin 2004)

Table 6: rationale for immobilisation

5.112 Positioning in the Acute Stage

Modify according to burn area, patient pain and medical status.

Area Of Burn	**Common Contracture**	**Recommended position**
Anterior neck	Neck flexion: loss of neck contours and extension	Neck in extension. If head needs to be raised, do not use pillows.
Posterior neck	Neck extension. Loss of flexion and other movements	Head in flexion. Sitting or lying with a pillow behind the head.
Axilla	Limited abduction/ protraction with burn to chest	Lying/ sitting with arms abducted. Slings, pillows, figure of eight bandage around chest for stretch. Prone lying
Anterior Elbows	Flexion	Elbow extension
Groin	Hip flexion	Prone lying, legs extended, no pillow under knees in supine, limit sitting/side lying
Back of knee	Flexion	Long sitting/ supine lying, no pillow beneath knees
Feet	Dependent on area	Aim to maintain 90 degrees at ankle: pillows in bed, sitting with feet on floor
Face	Variety: inability to open/close mouth/eyelids	Regular change of expression. Soft rolls may be inserted into the mouth

Table 7 Positions of immobilisation, for pictures, see Procter, 2010

<u>5.113 1mmobilisation post skin reconstruction surgery</u>

Stopping movement and function of the body parts involved should be enforced after skin reconstruction for a burn has taken place. When a body part must be immobilised, it should be splinted or positioned in an anti-deformity position for the minimum length of time possible (Edgar and Brereton 2004; ANZBA 2007)

The following is a table drawn up using current literature on the recommended immobilisation times for the various skin grafts:

Surgical Procedure	**Immobilisation Time**
Biological Dressings	<24hours
Autograft (superficial to intermediate)	24-48hours
STSG	3-5 days
FTSG	5-7 days

Table 8 Surgical procedure and related immobilisation (ANZBA 2007; Edgar and Brereton 2004)

The times frames for mobilisation post-surgery outlined in this booklet are merely a guide taken from an analysis of current literature and are NOT a replacement for the specific time frames directed by the operating surgeon or consultant (ANZBA 2007).

For a physiotherapist the most important **concepts** to grasp are:

- What is the minimum timeframe of immobilisation post-surgery
- What structures MUST be immobilised
- Special considerations for movement, function and ambulation dependent on

    Donor sites and the structures repaired or excised during surgery.

5.114 Immobilisation of the hand

Deformity Prevention

The most common deformity associated with burns is the ‘claw’ deformity. It involves extension of the MCP joints, flexion of the PIP joints, adduction of the thumb and flexion of the wrist (Kamolz 2009). This position is also referred to as the intrinsic minus position.

Figure16a. Dorsal hand burn resulting in claw deformity

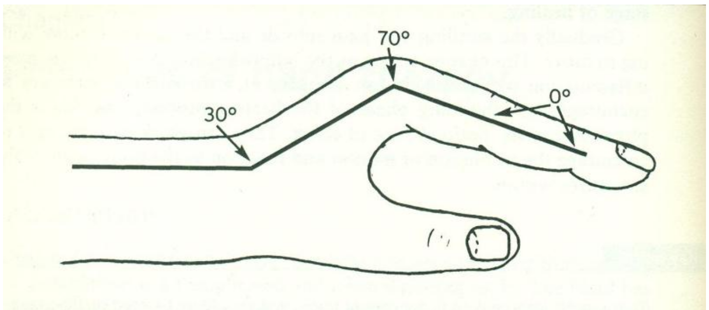


Figure 16 b: Position of safe immobilisation (Glassey, 2004)

Position of Safe Immobilisation

The position of safe immobilisation of the burned hand is essentially the opposite of the above claw deformity position. This position involves: 20-30 wrist extension, 80-90 degrees flexion MCP joints, full extension PIP and DIP joints and palmar abduction of the thumb (Boscheinen-Morrin 2004).

5.115 Splinting

Physiological rationale for splinting (Kwan 2002)

Scar tissue is visco-elastic. It will elongate steadily within a certain range. When this stretching force is released, there is an immediate decrease in the tissue tension but a delay in the retractions of the tissue to a shorter length. These stress relaxation properties of visco elastic scar tissue means it can accommodate to stretching force overtime. Dynamic and static splinting provide this prolonged low stretching force.

Categories of Splints

- Static or Dynamic
- Supportive or Corrective
- Rigid or soft
- Dorsal or Volar
- Digit, hand or forearm based (Boscheinen-Morrin 2004)

Static Splinting

- A **serial static splint** is a device with no moving parts designed to be remoulded as a contracture improves. The most common serial static splint you will come across is a thermoplastic palmar splint moulded in the position of safe immobilisation.


Fig 17: Thermoplastic palmar splints in the position of safe immobilisation (Glassey 2004)

- A **static progressive splint** is a device designed to stretch contractures through the application of incrementally adjusted static force to promote lengthening of contracted tissue (Smiths 2009). There are various types of static progressive splints available depending on the area affected. One such static progressive splint is a finger flexion strap splint. This type of splint is used in the treatment of MCP extension contractures. The flexion straps serially stretch scar bands along the dorsum of hand and wrist causing extension contracture. The stretching force is localised to the MCP joints by applying the straps via a wrist extension splint. This stabilises the wrist providing static support below the MCP joint (Kwan 2002).

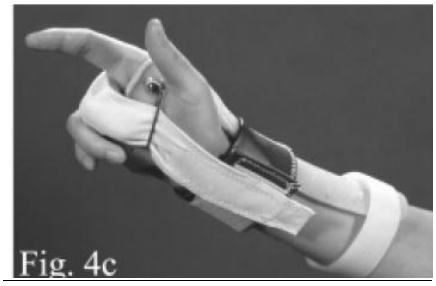


Fig 18: Velcro flexion straps

(Glassey 2004)

Dynamic Splinting

A **dynamic splint** is one which aids in initiating and performing movements by controlling the plane and range of motion of the injured part. It applies a mobile force in one direction while allowing active motion in the opposite direction. This mobile force is usually applied with rubber bands, elastics and springs (Smith 2009).

Dynamic **extension** splints are most commonly used in the treatment of palmar and / or finger burns (i.e. flexion contractures). All the finger joints including the MCP, PIP and DIP joints are in full extension (Smith 2009).

Fig 19 Dynamic Extension Hand Splint (Microsurgeon 2013)

Dynamic **flexion** splints are used in the treatment of dorsal hand burns. During wound healing and subsequent scar maturation, the skin on the dorsal aspect of the hand can markedly contract limiting digit flexion. A dynamic flexion splint in the sub-acute stage of dorsal hand burns can aid in the prevention of MCP joint extension contractures (Kwan 2002).

Fig 20 Dynamic flexion hand splint in glove form (Microsurgeon 2013)

Overview of the Evidence:

There is currently no evidence available which identifies the benefit of one hand splint over another in the treatment of the burnt hand. A systematic review carried out in 2006 concluded that there are no studies examining the effectiveness of hand splinting for hand burns, but rather studies describing types of hand splint interventions (Esselman 2006). There are currently no control trials which compares the various types of splints available or which examines the use Vs disuse of splinting the burnt hand. Literature in the area suggests the use of splinting in the initial inflammatory phase to promote a position of safe immobilisation. The use of splinting as an adjunct to treatment in the sub-acute phase is discussed in the literature as an aid to maintain/regain range of motion.

Splinting Precautions

- Splints need to be cleaned regularly to prevent colonization by microbes which may lead to wound infection (Wright et al 1989; Faoagali et al 1994)
- Unnecessary use of splinting may cause venous and lymphatic stasis, which may result in an increase in oedema (Palmada et al 1999)
- Precaution must be taken to ensure that splints do not product friction causing unnecessary trauma to the soft tissues (Duncan et al 1989).
- Precaution must be taken to ensure that splints do not produce excessive pressure. There is particular risk of pressure injury to skin after burn injuries due to potential skin anaesthesia (Leong 1997).
- Splinting should not be used in isolation but as an adjunct to a treatment regime

Conclusion on Splinting

The use of hand splinting does not follow a protocol in the treatment of the burnt hand. It is often common practice to splint the burnt hand in the initially inflammatory phase of healing. Despite the level of evidence available it is important as a physiotherapist to be aware of the role splinting can play as an adjunct to treatment of the burnt hand in the sub-acute phase of healing. The application of hand splinting in the areas of burns must be clinically reasoned for each individual patient. A Physiotherapist must identify the appropriate rather than routine use of splinting. This is to promote patient independence and prevent dependence on splinting devices both by patients and physiotherapists alike.

5.12 Management of Oedema

5.121 Elevation

Elevation of the hand above heart level is the most simple and effective ways to prevent and decrease oedema (Kamolz 2009). A Bradford sling can be used to facilitate elevation. This type of sling facilitates both elevation and protection of wound area while still allowing movement. Its foam design also reduces the risk of the development of pressure points or friction (Glassey 2004).

Fig 21. Bradford sling in a position of elevation (Microsurgeon 2013)

When a patient is admitted with severe burns of a large TBSA they are at risk of systemic inflammation. Therefore, not only must the affected limb be placed in elevation, the following precautions should also be taken

- Elevation of the head: This aids chest clearance, reduces swelling of head, neck and upper airways. It is important not place a pillow underneath the head in the case of anterior neck burns as there is a risk of neck flexion contractures
- Elevate all limbs effected
- Feet should be kept at 90
- Neutral position of hips
- Care must be taken to reduce the risk of pressure sores. (Procter 2010)

5.122 Coban

Coban wrap can be used to decrease hand oedema. The main advantage of Coban wrap is that it does not stick to underlying tissue, making it suitable for use in the acute stages of burns (Lowell 2003). There is currently limited quantity of evidence to support the use of Coban wrap in the treatment of Oedema. In 2003 Lowell et al carried out a case study involving a subject with dorsal hand burns.

Subject: 59 year old male with 46% TBSA thermal burn. Bilateral dorsal hand burns included.

Intervention: Day 3 post skin grafting left hand wrapped in standard gauze dressing, right hand wrapped in coban self-adherent wrap. On post-op day 11 coban wrap applied to both hands.

Outcome measures: 1) Circumferential of oedema measurement at level of MCP, DIP and PIP 2) Range of motion 3) Grip Strength 4) Nine hole peg dexterity test

Results: Significantly decreased oedema in the right hand versus control hand at 11 days post op. Decreased oedema bilaterally post op day 17. Improved grip strength in right hand versus control hand 17 days post op. Improved dexterity and ROM in right hand versus control hand 21 days post op

Limitations: Hand dominance not established, single subject study

5.123 Oedema Glove/Digi Sleeve

These are hand specific oedema management products. There is currently no specific evidence available to support the efficacy of oedema gloves or digi sleeves in the reduction of oedema. However it is common practice in Irish hospital to provide these products to patients with excessive hand and finger oedema. Their use is based on the principle of compression to reduce oedema which is heavily supported by evidence (Latham and Radomski 2008).

Fig 22 Oedema glove
(Microsurgeon 2013)

Fig 23 Digi sleeve
(Microsurgeon 2013)

5.2 Role of the Physiotherapist in the Rehabilitation of the Sub Acute Burn Patient

Beyond the acute stage of immobilisation, inpatient and outpatient rehabilitation typically consists of a variety of interventions including pressure garment therapy, silicone therapy, scar massage, range of motion and mobilisation techniques, strengthening, functional and gait retraining, and balance and fine motor retraining (Schneider et al, 2012). Interventions should be tailored according to a full patient assessment.

As it would be unethical to withhold treatment, physiotherapy intervention as a whole is not well investigated. Schneider et al (2012) found a significant improvement in contractures; balance and hand function with inpatient rehabilitation, through a longitudinal observational study of eleven people. However, in the following section, we will attempt to display the evidence for commonly used modalities.

The patient

- Primary closure of wound
- Scar remodelling
- Scar contraction

Aims

- Optimise scar appearance
- Limit effects of scar contraction/prolonged positioning on range of motion and function
- Address effects of prolonged bed rest

Common modalities

- Mobilisation- both mobility and specific joint mobilisation
- Scar management adjuncts
    - Pressure garments, silicone, massage
- Continuation of oedema/ positioning management where necessary

5.21 Mobilisation

The advantages of general mobilisation for a burns patient to counteract the effects of prolonged bed rest are no different to that of a surgical or medical patient. Burns patients should be mobilised as early as possible to avoid deconditioning and possible respiratory complications associated with prolonged bed rest (Esselman 2007).

As outlined in the above introduction, due to the ethical issues surrounding withdrawal or modification of treatment the evidence surround the optimal duration, frequency and methods of physiotherapy interventions in the treatment of burn patients is unclear. Despite this lack of clarify surrounding these issues it is clear that both active and passive mobilisation plays a key role throughout the stages of burn recovery. Below is a summary of the recommendations from the currently literature on passive and active mobilisation of burns.

5.211 Active ROM

- Depending on the need for immobilisation gentle active ROM exercises is the preferred treatment during the acute stage of injury as it is the most effective means of reducing oedema by means of active muscle contraction (Glassey 2004). If this is not possible due to sedation, surgical intervention etc. then positioning the patient is the next best alternative (see immobilisation and position).

5.212 Passive ROM

- Passive ROM exercises in the acute stage are contraindicated as applying passive stretching forces may result in future damage to the burned structures (Boscheinen-Morrin 2004). Applying these passive manoeuvres in the acute stage will result in increased oedema, haemorrhage and fibrosis of the burned tissues (Cooper 2007).
- The biomechanical principle of creep when passive stretching. A slow sustained stretch is more tolerable for patient and more effective for producing lengthening (Kwan 2002).
- Passive joint mobilisations can begin during the scar maturation phase once the scar tissue has adequate tensile strength to tolerate friction caused by mobilisation techniques (Boscheinen-Morrin and Connolly 2001).

Frequency, Duration Recommendations

- Physiotherapy intervention should be twice daily with patients prescribed frequent active exercises in between sessions.
- For the sedated patient gentle passive range of motion exercises should be done 3 times a day once indicated (Boscheinen-Morrin and Connolly 2001).
- Dependent on the severity of the burn active and very gentle passive range of motion exercises for the hand and fingers are begun from day one of injury.

Contraindications

- Active or Passive range of motion exercises should not be carried out if there is suspected damage to extensor tendons (common occurrence with deep dermal and full thickness burns). Flexion of the PIP joints should be avoided at all costs to prevent extensor tendon rupture. The hand should be splinted in the position of safe immobilisation or alternatively a volar PIP extension splint until surgical intervention (Boscheinen-Morrin and Connolly 2001) is discussed.
- Range of motion exercises are also contraindicated post skin grafting as a period of 3-5 days immobilisation is required to enable graft healing (Boscheinen-Morrin and Connolly 2001).

Evidence for hand mobilisation

There is currently limited evidence which examines the effectiveness of hand exercises for the burned hand specifically. Studies in the area of burns generally include subjects who have extensive % TBSA in which their hand/hands may be involved.

Okhovation et al (2007) carried out an RCT in which they compared a routine rehabilitation protocol with a burn rehabilitation protocol. This study is particularly relevant form a hand burn rehabilitation perspective as 83% of subjects recruited had partial / full thickness hand burns

Subjects: 30 burn admissions to Tehran Hospital in 2005. Matched in pairs based on clinical details (sex, age, TBSA, depth of burn). Randomly assigned into two groups

Intervention: The routine rehabilitation protocol included chest physiotherapy and active/passive movements 15-20 minutes daily commenced 2/52 post admission. The burn rehabilitation protocol involved routine protocol plus targeted stretching program to contracture risk areas for 30-45min 2-3times daily commenced on day1 of admission. **Outcome measures:** Outcome measures used were Presence of burn contracture (goniometry) Occurrence of thrombosis Length of Hospital Stay Skin grafting requirement.

Results: Development of post burn contractures on discharge from hospital was 6% in the burn rehabilitation group versus 73% in the routine rehabilitation group. No significant difference regarding thrombosis, duration of stay and number of skin grafts

Limitations: There were several limitations to the study. The recruitment process was not clearly defined. Information on the group matching and randomised allocation process was not provided. No inclusion/exclusion criterion was defined. Frequency, duration and commencement of the two protocols unequal and appear very bias towards targeted stretching program.

Functional Rehabilitation of the Hand

Salter and Chesire (2000) suggest that the burnt hand should be used for light self-care activities as soon as tolerated by the patient. This is based on the principle that everyday activities will promote regular movement patterns of the affected hand. Emphasis should be placed on intrinsic flexion of the MCP joints and intrinsic IP joint extension, gross gripping (i.e. composite flexion), maintenance of the web spaces and opposition of the thumb.

Practical factors to consider when mobilising

- Be aware of dressing clinic/daily dressing changes. Mobilisation should coincide with this as it is important to monitor the wound during AROM frequently.
- Timing of pain relief. This should be timed appropriately to ensure maximal benefit during treatment sessions.
- Observe the patient carrying out the AROM and PROM exercises prior to beginning treatment. Also observe the patient taking on/off splints.
- Always monitor for post exercise pain and wound breakdown.
- Avoid blanching for long period as you may compromise vascularity.
- The patient may present with a reduced capacity for exercise secondary to increased metabolic rate, altered thermoregulation and increased nutritional demands.
- Postural hypotension may be present due to prolonged bed rest and low haemoglobin. (ANZBA 2007)

5.22 Scar Management

Abnormal scarring is the most common complication of burn injuries, with the estimated prevalence of > 70% of those who suffer burn injuries (Anzarut et al, 2009). Not only do hypertrophic scars cause psychosocial difficulties through their cosmetic appearance, they may also be painful, pruritic, and they may limit range of motion where they occur on or near a joint (Morien et al 2009; Polotto 2011).

Hypertrophic scars require a continuum of dedicated and specialised treatment from the acute stage to many years post treatment (Procter, 2010, ANZBA 2007).

The following is an examination of the evidence and recommendations for use in the most common of these, including silicone gel, pressure garment therapy, and massage. The positioning and mobilisation advice above is all applicable, and should be continued in the management of hypertrophic scars where necessary.

5.221 Scar Outcome Measures

1. Vancouver Burn Scar Scale (VBSS/VSS)
2. Patient and Observer Scar Assessment Scale (POSAS)

Vancouver Burn Scar Scale (VBSS/VSS)

Use: Most familiar burn scar assessment. Measures: pigmentation, pliability, thickness and vascularisation (Fearmonti et al 2010).

Reliability: Not enough evidence to make it a 'gold standard' OCM. Moderate to high overall inter rater reliability. Test- Retest and intra – rater reliability has not been assessed for burn scars to date (Durani et al 2009).

Validity: When compared with POSAS scale, validity was evident (Durani et al 2009)

Sensitivity: Most Scar OCM rely on categorical/ordinal data with few levels which provides limited sensitivity and can only identify considerable differences between scars (Fearmonti et al 2010).

Patient and Observer Scar Assessment Scale (POSAS)

Use: Measures pigmentation, vascularity, thickness, relief, pliability and surface area. Also includes assessment of patient pain, itching, colour, stiffness, thickness and relief. The only scale to measure subjective aspects of pain and pruritus (severe itching) (Fearmonti et al 2010).

Reliability: Good internal consistency and reliability (Durani et al 2009)

Validity: Good concurrent validity (Durani et al 2009)

Sensitivity: Like the VBSS/VSS above, limited sensitivity due to categorical/ordinal data (Fearmonti et al 2010)

Further studies are required to validate the reliability and validity of these scales as they are considered to be very subjective measures (Durani et al 2009). Scar scales like the Vancouver Burn Scar Scale (VBSS/VSS) and the Patient and Observer Scar Assessment Scale (POSAS) are cost effective and can be easily transferred within a clinical setting. To optimise the scar scales, photographic evidence of the scar at timed intervals is of great value also to the clinician (Brusselaers et al 2010)

5.222 Silicone

Silicone Overview

The use of silicone gel or sheeting to prevent and treat hypertrophic scarring is still relatively new. It began in 1981 with treatment of burn scars (O'Brien & Pandit 2008). The physiological effects of silicone in the treatment of scarring remain unclear. Below is a summary of the current hypotheses surrounding the physiological effects of silicone. This summary has been adapted from the most recently published literature on this topic.

1) Hydration Effect: Hydration can be caused by the occlusion of the underlying skin. It decreases capillary activity and collagen production, through inhibition of the proliferation of fibroblasts
2) Increase in temperature: A rise in temperature increases collagenase activity thus increased scar breakdown.

3) Polarized Electric Fields: The negative charge within silicone causes polarization of the scar tissue, resulting in involution of the scar.
4) Presence of silicone oil: The presence of silicone has been detected in the stratum corneum of skin exposed to silicone. However other researchers suggest occlusive products without silicone show similar results.
5) Oxygen tension: After silicone treatment the hydrated stratum corneum is more permeable to oxygen and thus oxygen tension in the epidermis and upper dermis rises. Increased oxygen tension will inhibit the ‘‘hypoxia signal’’ from this tissue. Hypoxia is a stimulus to angiogenesis and tissue growth in wound healing, as a consequence removing the hypoxia stops new tissue growth. This theory has been contraindicated by other researchers.
6) Mast cells: It is suggested that silicone results in an increase of mast cells in the cellular matrix of the scar with subsequent accelerated remodelling of the tissue.
7) Static electricity: Static electricity on silicone may influence the alignment of collagen deposition (negative static electric field generated by friction between silicone gel/sheets and the skin could cause collagen realignment and result in the involution of scars. (Bloemen et al 2009; Momeni et al 2009)

<u>Evidence</u>

Momeni et al 2009: RCT, double blind placebo controlled trial

Subjects: N=38, with hypertrophic scars post thermal burn. All were 2-4 months post burn, with areas including upper limb (n=14) lower limb (n=8) trunk (n=3) and face (n=9).

Intervention: Patients acted as their own control, with the scar area being randomly divided into two sections: one received silicone sheets, and the other a placebo. Both were applied for 4hrs/day initially, with this incrementally increased to 24 hrs/day over the course of the study, for a four month period.

Outcome measures: assessed at one and four months, by a blinded assessor using the Vancouver Scar Scale and by Clinical Appearance.

Results: No significant differences in baseline characteristics. At one month the silicone group had lower scar scores than the placebo group, however they were not statistically significant. At four months, the silicone group had significantly lower scores on VSS for all dimensions except pain compared to placebo.

Limitations: Small heterogeneous cohort. No discussion of clinical significance of the reduction in scar scales. 4 subjects lost to follow up with no intention to treat analysis.

Brien and Pandit 2008: Cochrane Systematic Review Investigating the Efficacy of Silicone Gel Sheeting in Preventing and Treating Hypertrophic and Keloid Scars

Studies Included: 15 RCTs, n=615, only 3 studies specific to burn patients. 12 compared silicone to no treatment, and the remainder silicone was compared to placebo or laser treatment.

Outcome Measures: Primary outcome measures included scar length, width and thickness; secondary outcomes include scar appearance, colour, elasticity, relief of itching/pain

Results: No significant difference between silicone gel sheeting and control in reducing scar length and width. Significant results for reducing scar thickness, though these were thought not to be clinically relevant. No statistically significant difference between silicone gel and controls in secondary outcomes.

Limitations: Large age range, heterogeneous sample, poor quality of trials in general, with most at high risk of selection and detection bias. Only three studies used blinded outcome measures. 6 studies lost >10% of participants to follow up.

Conclusion on Silicone

It is unclear whether silicone gel help prevent scarring. Many of the studies advocating the use of silicone gel are of poor quality and are susceptible to bias. However, it is currently common practice in Ireland to administered silicone gel as an adjunct to treatment of scarring. Silicone gel as opposed to sheets is the preferred product to use as it is easier to apply can be used on more areas of the body and gives a higher patient compliance (Bloemen et al 2009).

5.223 Pressure Garment Therapy (PGT)

Though the effectiveness of PGT has never been proven, it is a common treatment modality for reducing oedema and managing hypertrophic scars (Procter, 2010).

Aims

- Reduce scarring by hastening maturation
    - Pressure decreases blood flow
    - Local hypoxia of hypervascular scars
    - Reduction in collagen deposition
- Therefore
    - Decreases scar thickness
    - Decreases scar redness
    - Decreases swelling
    - Reduces itch
    - Protects new skin/grafts
    - Maintains contours (Procter 2010)

The exact physiological effects of how pressure positively influences the maturation of hypertrophic scars remain unclear. Below is a summary of the current hypotheses surrounding the physiological effects of pressure garments. This summary has been adapted from the most recently published literature on

1) Hydration effect: decreased scar hydration results in mast cell stabilization and a subsequent decrease in neurovascularisation and extracellular matrix production. However this hypothesis is in contrast with a mechanism of action of silicone, in which an increase of mast cells causes scar maturation.
2) Blood flow: a decrease in blood flow causes excessive hypoxia resulting in fibroblast degeneration and decreased levels of chondroitin-4-sulfate, with a subsequent increase in collagen degradation.
3) Prostaglandin E2 release: Induction of prostaglandin E2 release, which can block fibroblast proliferation as well as collagen production

(MacIntyre & Baird 2006)

Evidence

The evidence for PGT is limited.

- Early studies found significant benefit from their use in terms of scar maturation and necessity of surgery for correction
- These were not RCTs, and were conducted in a time where inefficient surgical debridement resulted in scar loads much worse than those seen today (Engrav et al 2010)

Article citation and design	Anzarut et al (2009) Systematic Review+ Meta-Analysis	Engrav et al (2010) Within wound RCT
Selection criteria	6 trials with 316 patients located 3 between-subject design 3 studies within-subject design Adult and paediatric populations	54 patients recruited over 12 years Forearm burn requiring >3 weeks to heal/skin grafting. Mean age, 36 yrs, mean length of follow up, 9.5 months
Intervention	3 studies wore pressure garments for 23h/day 3 studies did not describe length of pressure garment treatment	Randomised normal compression (17- 25mmHg) and low compression (<5 mmHg) to proximal/distal area of scar. 23 hrs/ day to wound maturity, or up to 1 yr
Outcome measures	Primary Outcome: Global scar score Secondary outcome: Scar height, vascularity, pliability, colour	Durometry (hardness) colorimetry (colour) ultrasonography (thickness) Clinical appearance: judged by a panel of 11 experts in burn care
Results	Global Scar Score: • No significant differences between PGT & control interventions Secondary Outcome:	• Statistically significant decrease in scar hardness and height • 3/19 and 5/28 patients respectively achieved a decrease which could be

	• Scar height showed a small but statistically significant decrease in height for pressure garment therapy. • Questionable if this is clinically significant. • Scar vascularity, pliability and colour failed to demonstrate a different between groups	clinically detected • In only 3/41 patients could the zone of normal and low compression be identified correctly by a panel of 11 experts However, the authors concluded by recommending that PGT should continue to be used.
Limitations	Publication bias present with only 1 trial reported negative effect In 5 of the 6 studies, concealment of allocation was unclear All studies had inadequate reporting of randomisation and did not comment on withdrawals and dropouts.	Some data lost for different parameters over the space of 12 years. Noted that in this time, staff and equipment changed, which could have confounded results. Evidence of bias in interpretation of results. Low risk of bias from randomisation, not all assesors blinded.

Table 9 Available Evidence for PGT

- The authors' bias was evident in both of the above articles. Though their results were similar, Anzarut et al, 2009 concluded that there was no evidence to justify this 'expensive source of patient discomfort', while Engrav et al, 2010 concluded that its use was justified.

Patient Adherence to Pressure Garment Therapy

In 2009 Ripper et al carried out a quantitative study on adult burn patient's adherence to pressure garment therapy.

Subjects: 21 participates interviewed concerning their experiences with pressure garments. Time since burn ranged from 5months to 4years and 2 months.

Methodology: Randomised selection of patients 21 patients segregated into 3 groups: Patients who had completed PGT, Patients who were still in the course of therapy, and Patients who refused to wear the garments and had stopped PTG completely.

Results: Complaints most frequently mentioned were: “Physical and Functional limitations” caused by garments. “Additional effort” created by the need to care for the garment. Motivating factors for the patients: ‘expectation of success’ ‘emotional support’ ‘practical support’ and experiencing ‘good outcome’.

Limitation: Unclear method of randomised selection, variation in time elapsed since burns, body parts affected by burns not established

Careful considerations of cost, compliance, patient discomfort, possible complications and the perceived benefits before prescribing this treatment.

Recommendations for practice and safety considerations

Pressure: **15 mmHg** has been noted as the minimum to elicit change, and pressures of above **40 mmHg** have been found to cause complications. Both Anzarut et al (2009) and Engrav et al (2010) used pressures of between 15 and 25 mmHg.

Time: It is recommended that garments are worn for up to **23 hours a day**, with removal for cleaning of the wound and garment, and moisturisation of the wound. (Procter 2010; Anzarut et al 2009 and Bloeman et al 2009).

Duration: garments can be worn as soon as **wound closure** has been obtained, and the scar is stable enough to tolerate pressure. Post grafting, **10-14 days** wait is recommended, at the discretion of the surgeon (Bloeman et al 2009). Garments should be worn for up to one year, or until scar maturation (Anzarut et al 2009; Engrav et al 2010 and Bloeman et al 2009).

Possible complications/ confounding factors for use of PGT

- Lack of a scientific evidence to established optimum pressure
- Non-Compliance (due to comfort, movement, appearance)
- Heat and perspiration
- Swelling of extremities caused by inhibited venous return
- Skin breakdown
- Web space discomfort
- Inconvenience
- Personal hygiene difficulties possibility of infection
- Allergies to material (MacIntyre & Baird 2006; Glassey 2004)

5.224 Massage

Five principles of scar massage:

1. Prevent adherence
2. Reduce redness
3. Reduce elevation of scar tissue
4. Relieve pruritus
5. Moisturise (Glassey 2004)

Scar Massage Techniques

- Retrograde massage to aid venous return, increase lymphatic drainage, mobilise fluid
- Effleurage to increase circulation
- Static pressure to reduce pockets of swelling
- Finger and thumb kneading to mobilise the scar and surrounding tissue
- Skin rolling to restore mobility to tissue interfaces
- Wringing the scar to stretch and promote collagenous remodelling
- Frictions to loosen adhesions

(Holey and Cook 2003)

Guidelines for Massage during 3 Stages of healing	
Inflammatory Phase	gentle massage to decrease oedema and increase blood supply (currently no high level evidence to support this)
Proliferative Phase	Massage that applies gentle stress to the healing scar is recommended to ensure collagen is aligned correctly.
Remodelling Phase	Massage should be progressed to include prolonged stretching to minimise adhesions. This is proposed to aid in scar tissue breakdown

Table 10 Guidelines for scar massage during healing stages (Glassey 2004)

Table 11. Evidence for the use of massage in scar management

Article	Field et al 2000 RCT	Morien et al 2008 Pilot Study	Shin and Bordeaux, 2012 Lit review
Subjects	20 subjects in remodelling phase of wound healing. Randomly assigned into 2 groups Massage Vs Control	8 Children Mean age 13.5 years (10-17years) All thermal burns including hand burns	Not burn specific, though the majority of scars were of this origin 10 articles: n=144 adult and children
Intervention	Massage Therapy Group: 30minutes massage with cocoa butter twice weekly for 5 weeks Control Group: Standard Treatment	20-25 minute massage session once daily for 5 days (effleurage, petrissage, friction, lengthening rolling) Session followed by discussion of psychosocial issues	Time to Rx: mean 4.3 months. + variation in protocols. 20 mins/day- 30 mins 2x weekly. 1 Rx-6 months Rx
Outcome measures	Itching: VAS Pain: McGill Pain Questionnaire Anxiety: State Trait Anxiety Inventory Mood: Profile of Mood States	Likert pictorial scale Goniometry Range of Motion	Patient and observer scar assessment scale, Vancouver scar scale, thickness, vascularity, colour, pain, pruritus, mood, anxiety, and depression.
Results	Massage Therapy Group Reported: decreased itching, pain, anxiety and increased mood Ratings improved from the 1st -last day of the study	Increased ROM in massaged tissue. Decreased ROM in unmassaged tissue No significant difference in mood across time	45.7% improved in at least one of the above parameters. 54.7% had no improvement. Noted massage was more economical than silicone/PGT.

Limitations	Small Sample Size No follow up	Paediatric population. Mood Instrument may have been influenced by other factors. Recruitment and area to be massaged not random Small sample size No follow up	No discussion of quality or statistical tests.

Conclusion on Scar Massage

Evidence suggests that burn patients receive psychological benefits from massage in terms of altered mood (decreased depression, anger), decreased pain, and anxiety (Field et al 1998). Evidence also indicates that massage increases ROM in non-burned patients, but little evidence exist examining the effect of massage on ROM in burn patients (Morien et al 2008).

Recommendations for practice and safety considerations.

Insufficient consistency in literature with regards to protocols on frequency or duration of treatment. Suggestions for practice include (Shin and Bordeaux, 2012, Morien et al, 2008)

- Clean hands essential
- Use non irritating lubricant, free of any known sensitisers.
- Modify practice according to patient stage of healing, sensitivity and pain levels.

Contraindications: Shin and Bordeaux 2012

- Compromised integrity of epidermis
- Acute infection
- Bleeding
- Wound dehiscence,
- Graft failure
- Intolerable discomfort
- Hypersensitivity to emollient

5.3 The Role of the Physiotherapist in the Rehabilitation of the Chronic Burn Patient.

The patient

- Healing process may continue for up to two years, as scar tissue remodels and matures
- May require functional retraining and integration back into the community and activities.

It is important to note that though scar management is initiated in the sub-acute phase, it may need to be continued long term, as many patients suffer from continuing limitation to range of motion (Procter 2010).

5.31 Aerobic and Resistance Training Post Burn

5.311 Rationale for Aerobic and Resistance Training

- Low cardiorespiratory endurance has been found to be a concern for all (Willis et al 2011)
- Aerobic capacity as measured by VO2 peak and time to fatigue has been found to be lower in adults and children of >15% TBSA at one year post burn, compared to age matched healthy controls (Willis et al 2011; McEntine et al 2006)
- Muscular strength and lean body mass has been found to be significantly less in patients suffering from burns of >30% TBSA, particularly in exercises requiring a high velocity (Disseldorp et al 2007; Ebid et al 2012). The systemic effects caused by large surface area burns means that weakness may be global, not just local to the site of the injury (Grisbrook et al 2012b)
- Reduced lean body mass, endurance and strength has been associated with limited standing/walking tolerance, reduced upper limb function and lower health related QOL and ability to participate in activities (Grisbrook et al 2012b).
- This has been found to persist beyond discharge from hospital despite routine physiotherapy and occupational therapy in hospital (Disseldorp et al 2007). Though protein metabolism begins to normalise 9-12 months post burn, patients are still found

to have significant strength and aerobic related functional impairment at >2 years post burn (Grisbrook et al 2012b).

It is proposed that aerobic capacity and muscular strength is diminished by the following factors

- Prolonged bed rest necessary in the early recovery process
- Hypermetabolisim, which may lead to *
  - Exhaustion
  - Protein catabolism
  - Loss of lean body mass
- Impaired thermoregulation **
- Inhalation injuries and compromised respiratory function***

Recovery of aerobic capacity and strength may also be limited by

- Fatigue
- Pain
- Psychosocial factors

(Disseldorp et al 2011; De Lauter et al 2007; Grisbrook et al 2012; Suman and Herndon 2007)

*<u>Hyper metabolism, catabolism, loss of lean body mass and exhaustion</u>

Hypermetabolisim post burn caused by both second and third degree burns, particularly if sepsis follows. This may begin approximately five days post burn, as the metabolic state is initially suppressed by the effects of acute shock, and can persist for up to two years post injury (Jeschke et al 2007; Herndon and Tomkins 2004). The greater the TBSA, the greater the risk and impact of hyper metabolism (Hurt et al 2000). While it may not be recognised in the acute stages, it may give rise to long term complications and functional impairment, particularly with respect to strength and aerobic capacity (De Lauter et al 2007).

A systematic review by Disseldorp et al (2007) found 4 studies involving children with > 40% TBSA

- All found a decrease of up to 20% in lean muscle mass compared to age matched controls
- Adults with a TBSA >30% suffered a significant decrease in torque, work and power in the quadriceps muscles compared to age matched controls. (De Lauter et al 2007)

Exercise and Hypermetabolism

Though exercise requires an increase in energy expenditure and metabolism for a short period of time no adverse effects have been found with regard to exacerbating hypermetabolism or protein catabolism.

- All studies investigating the effects of exercise on lean body mass found it to increase, particularly with resistance training (Grisbrook et al 2012b; Suman and Herndon 2007; Suman et al 2001; Przkora et al 2007)
- Suman et al, 2001, found an increase of 15% in resting energy expenditure in children with burns of >40% TBSA who were not treated with resistance and aerobic exercise, while the REE of those who participated in the intervention remained stable.
    - Suggested that exercise may have sympathetic nervous system attenuating effects
        - A balance of resistance and aerobic exercise may cause a decrease in SNS activity, decreasing catabolic effects.
- Exercise is required to integrate dietary amino acids into lean muscle mass (Herndon and Tomkins 2004)

**Thermoregulation

Human skin produces sweat to dissipate heat in response to thermal stress (McEntine et al 2006). A proper sweat response requires functional integrity of the

- Sweat glands
- Skin circulation
- Neural control of the skin (McEntine et al 2006)

Full thickness burns damage the dermal appendages including sweat glands. These are not replaced by grafting. There is also a decreased density of sweat glands in the donor site post grafting (Esselman et al 2007).

However, McEntine et al 2006 found that in 15 children with an average of 55% TBSA there was

- No significant difference in core temperature, measured tympanically, pre or post 20 minutes of treadmill exercise at room temperature compared to age matched healthy controls.
- No significant difference in average skin temperature between burned and healthy children.
- Significantly increased skin temperature in healthy versus burned skin per child.

Austin et al, 2003 studied 3 adults with > 60% TBSA, 3 with between 30-40 TBSA and 2 unburned patients post 1 hr cycling at 35 degrees and 60% humidity

- None showed significant intolerance for heat as measured by heart rate and core temperature, measured rectally
- No significant difference in whole body sweat rate
- Overcompensation by healthy skin in the burned patients.
- Suggested physical history was a factor in determining patients' ability to thermoregulate. Therefore adaptations may occur through training.

However, studies involving heat loads of 40 degrees have found a significant inability to maintain adequate thermoregulation. Due to the small study numbers of the above, and the controversy surrounding the efficacy of measuring core temperature accurately, it is advised that patients are closely monitored initially during aerobic exercise for signs of heat intolerance.

***<u>Inhalation injury and pulmonary insufficiency</u>

Long term pulmonary function is compromised in some patients post severe burn

- Lasts several years
- Documented in both children and adults (Grisbrook et al 2012a)
- Caused by
    - Smoke inhalation
    - Direct thermal damage to airways
    - Pulmonary oedema

- Respiratory tract infection
- Complications from intubation
- Recurrent infection leading to chronic inflammation

Less likely to cause dysfunction in <30% TBSA, no injury over torso, and no inhalation injury

(Willis et al 2011)

Evidence for impact on aerobic and exercise capacity conflicting (Grisbrook et al 2012a). However Willis et al (2011) studied 8 males post > 15% TBSA burns at one year post injury, and found

- Significantly decreased FEV1, peak VO2 and time to fatigue, in the burned patients
- No significant decrease in SpO2 at baseline or peak VO2- however, the SpO2 of burned patients took significantly longer to stabilise at baseline post exercise.
- No significant difference in participation levels in physical activity, though burn survivors were more likely to participate in work rather than leisure activity.
- Burns survivors were less likely to participate in vigorous intensity exercise over 9 METs
- Therefore, decreased pulmonary function did not prevent them from participating
- The lower relative intensity of their exercise may have caused their decreased aerobic capacity.

All of the above factors must be considered as both a contributor to the patients' loss of strength and aerobic capacity, and a potential limiter of their ability to participate in therapy. Careful monitoring and modification of treatment according to individual response is advised.

5.312 Aerobic Training: The Evidence

Article citation	Disseldorp et al, 2011	De Lauteur et al, 2007	Grisbrook et al, 2012	Grisbrook et al, 2012	Paratz et al, 2012 (ab)	Przkora et al, 2007
Design	Systematic review Eleven articles included Eight RCTs Pedro 6+ 1 RCT<5, 1 non RCT, 2 static group comparison	Randomised controlled, double blinded trial	Non randomised controlled trial.	Non randomised controlled trial.	Quasi experimental controlled trial	Randomised controlled trial Oxandrolone, vs osandrolone + exercise, vs exercise + placebo, placebo+no exercise
Subjects	7 different cohorts 5 children with exceptionally large TBSA	35 adults mean 37.5 days post burn, mean TBSA 19.3%	9 burn injured adults and 9 age matched healthy controls. 20%+ TBSA, 2 yrs post injury, with remaining functional deficit.		30 patients, mean age 34.3 years, mean TBSA 42.9%	51 children, 7-17 yrs old, >40% TBSA
Intervention	Aimed to assess physical fitness post burn, and the effectiveness of aerobic exercise	12 week rehabilitation programme, 3 x weekly 30 mins. Standard rehabilitation vs. work to quota and work to tolerance aerobic exercise	12 weeks, 3 x weekly, 80 mins. 30 mins of treadmill walking/jogging in intervals (85 vs 65-70 HR max) and resistance exercises.		6weeks, 80 % MHR aerobic training, with 70% three RM resistance training	12 week inpatient physiotherapy twice daily for 1 hr. aerobic and resistance exercise Aerobic 5 days per week, 20-40 mins, 70-85% VO2peak
Outcome measure	Children and adults after extensive burns score worse than non-burned controls in all	Max aerobic capacity: VO2 max.	Spirometry, Canadian occupational performance measure, VO2 peak	Burn specific health scale, SF 36, quick DASH	1RM, VO2 peak, shuttle walk distance, LL function score, quick dash, burns	Biodex leg extension, 3 RM, VO2 peak, lean body mass,

	aspects of fitness. Burn patients participating in 12 week training programmes improve significantly more than those without.				specific health scale	
Results		Work to tolerance and work to quota significantly improved aerobic capacity. No significant improvement in control. No significant difference between WTQ and WTT	No significant improvement in spirometry values (ex/control) Significant improvement in VO2 peak and time to fatigue in both groups. Significant improvement in satisfaction with personalised goals.	Burns patients scored lower on HRQOL and quick dash both before and after the intervention compared to controls. 5/9 burn patients reached clinically significant improvements in BSHS post intervention. No significant increase in DASH	No adverse effects. Significant improvements in functional, physical, psychological measures.	LBM increased in all groups except placebo- showed average decrease. Steroids+ exercise= highest relative increase. Both exercise and drug only group showed significant increase in strength. Endurance increased in the exercise groups, but not those with only steroids/placebo
Limitations	4 studies conducted in children with large TBSA burns. Little variation in the protocols being compared, and so no objective evidence of the efficacy of individual components of exercise.	Low risk of bias in randomisation, no discussion of blinding to initial scores. Unable to blind therapists or patients to the intervention. Small patient numbers	Small subject numbers, no untreated control, blinding not possible	Small subject numbers, no untreated control, blinding not possible	Abstract. Unable to identify the methodological rigour of this study, and so results should be interpreted with caution.	Low risk of bias in randomisation, no discussion of blinding which leaves a high risk of bias where a placebo drug is involved.

Table 12 Evidence for Aerobic Training Post Burn

5.313 Aerobic Training Summary and Recommendations for Practice

Exercise prescription:

Frequency: The majority of papers which investigated an aerobic intervention used **3 times per week** as their frequency (De Lauteur et al 2007; Grisbrook et al 2012). These obtained significant improvements. However, Przkora et al (2007) used a frequency of 5 times per week with children. There have been no studies investigating optimal frequency.

Intensity: All studies used between **65 and 85% predicted heart rate max**, with one study using interval training of 120 seconds 85% HRM and 120 seconds of 65-70 HRM. All studies obtained positive effect, with none directly comparing intensities to determine the optimum. De Lauteur et al (2007), concluded that whether the patient gradually increased their intensity by working to a specific quota each week, or if they simply worked at their target heart rate for as long as they could tolerate, there was no significant difference in gains in aerobic capacity.

Type: All interventions used **treadmill training**, whether walking or running.

Time: All studies recommended the duration of treatment be **12 weeks**, with the exception of Paratz et al, 2012, who investigated a high intensity six week programme. However, the specific results of this are unknown. Sessions were **20-40 minutes in length**, with the majority using 30 minutes (Grisbrook et al 2012; De Lauteur et al 2007; Przkora et al 2007)

Please note safety considerations Pg 72

5.314 Resistance Training: The Evidence

Article citation	Disseldorp et al, 2011	Grisbrook et al, 2012 (a)	Grisbrook et al, 2012 (c)	Ebid et al, 2012	Suman and Herndon, 2007	Suman et al, 2001
Design	Systematic review Eleven articles included Eight RCTs Pedro 6+ 1 RCT<5, 1 non RCT, 2 static group comparison	Non randomised controlled trial.	Non randomised controlled trial.	Randomised controlled trial	Randomised controlled prospective study: effects of cessation of supervised exercise	Randomised controlled trial
Subjects	7 different cohorts 5 children with exceptionally large TBSA	9 burn injured adults and 9 age matched healthy controls. 20%+ TBSA, 2 yrs post injury, with remaining functional deficit.	9 burn injured adults and 9 age matched healthy controls. 20%+ TBSA, 2 yrs post injury, with remaining functional deficit.	N=14, 8 intervention, 6 control. >35% TBSA, aged 18-35, >3 months post burn, all with lower extremity burn	N=27, 11 intervention, 9 controls. TBSA > 40%, 7-18 yrs, > 6 months post burn.	N=35, 19 intervention, 16 controls, 7-17 yrs old, TBSA >40%, > 6 months post burn.
Intervention	Aimed to consolidate literature concerning, amongst others, the loss of muscular strength and effect of training in patients post burn	Aerobic + 3 sessions x week for 12 weeks. Exercise focused towards goals. Initially 50-60% 1 RM x 10-15 reps. Initially biodex, progressed to free weights and functional objects.	Aerobic + 3 sessions x week for 12 weeks. Exercise focused towards goals. Initially 50-60% 1 RM x 10-15 reps. Initially biodex, progressed to free weights and functional objects.	Isokinetic training supervised by PT vs HEP plus usual care. Isokinetics:3 times x week, 12 weeks, warm up plus five-10 sets of 3 reps quads and hams 60% peak torque	12 week individualised and supervised exercise training in hospital, vs HEP Exercise machines/free weights, 50-60% initially-80-85% 3RM. Plus aerobic training 20-40 mins, 3 x weekly. HEP on completion	12 week individualised and supervised exercise training in hospital, vs HEP Exercise machines/free weights, 50-60% initially-80-85% 3RM. Plus aerobic training 20-40 mins, 3 x weekly.

Outcome measure	6/6 studies which investigated strength found it was decreased in burn survivors compared to age matched controls. 5 studies investigated strength training, and all found significant increases post training.	Biodex. Muscle groups tested according to patients requirements for individual goals. DEXA for LBM	Canadian occupational performance measure	Biodex, peak torque, VAS, measurement of ambulation activity.	Isokinetic testing (Biodex). Peak torque, total work and average power. 3 RM, DXA.	Isokinetic testing (cybex norm dynamometer). Peak torque, total work and average power. 3 RM, DXA, VO2 peak, Resting energy expenditure.
Results		Both groups significantly improved hip flexor/extensor, shoulder flexor/extensor, and elbow flexor/extensor strength, and increased LBM	All participants displayed clinically significant improvements in performance and satisfaction in individual goals. COPM > 2 point increase.	Significant increase in peak torque and total work in intervention compared to controls. Average ambulation speed increased. 27.28% vs. 11.34 % improvement.	LBM and peak torque, work and power increased in the intervention group vs. controls. At 3 months post intervention, peak torque and LBM continued to rise in the intervention though not statistically significant, while remaining static in controls.	Significant increase in peak torque, total work and average power in intervention, not controls. LBM increased mean 6.4 %, Resting energy expenditure increased in controls, remained stable in exercise group
Limitations	4 studies conducted in children with large TBSA burns. Studies with smaller TBSA do not specify if the tested limb has been affected.	Small subject numbers, no untreated control, blinding not possible. Intervention not standardised, therefore not all muscle groups showed significant improvement.	Small subject numbers, no untreated control, blinding not possible.	Low risk of bias in randomisation, equal baseline characteristics, risk of bias in recruitment (by personal contact). Non blinded assessors/therapists . Small sample	No detail of randomisation or recruitment strategies. No discussion of blinding. Insufficient information to assess risk of bias. Small subject numbers, very specific group. No measurement of impact on daily activity or participation	No detail of randomisation or recruitment strategies. No discussion of blinding. Insufficient information to assess risk of bias. Small subject numbers, very specific group. No measurement of impact on daily activity or participation

5.314 Resistance Training Summary and Recommendations for Practice

Exercise prescription: Post two years, Grisbrook et al (2012b) found that burned patients responded to resistance exercise similarly to controls. Therefore, normal guidelines may be adequate.

Frequency: All studies investigating the effects of resistance training used a frequency of **three times** per week. There have been no studies to investigate the optimum frequency for resistance training in this population. Suman et al (2001), suggested that a break of more than **48 hrs** must be given between bouts of resistance training.

- Resistance exercise causes microtrauma to muscles already in a compromised state.
- Resistance exercise in burned patients stimulates protein synthesis as in unburned subjects- However; a longer period of recovery may be required for optimum results.

Type/ Intensity: Children: using free **weights or resistive machines:** 1 set of 50-60% of the patients 3 RM week 1, followed by a progression to 70-75% for week 2-6 (4-10 repetitions), and 80-85% week 7-12, (8-12 repetitions) (Suman et al 2001; Suman and Herndon 2007).

Isokinetic training: 10 reps at 150 degrees per second, using 1-5 sets for the 1st -5th session,6 sets for the 6th -24th session, and 10 sets from 25th to 36th session, with three minute rests between sets. (Ebid et al 2012).

Mixed and functional strength training: Grisbrook et al (2012b) commenced on the biodex, targeting specific muscle groups for the desired functional goal, and progressed to resistive machine and finally free weight training using functional items. Intensity was 50-60% of 1 RM initially, for 10-15 reps, adjusting as 1 RM increased. While no studies have compared the optimum type/intensity of exercise, this may be the optimum approach. Providing functional exercises may also increase motivation and compliance.

Time: All the studies used a protocol of **12 weeks**. There were no studies comparing the efficacy of shorter or longer time frames, however, given that loss of lean body mass is a possible cause of strength loss post burn, an exercise programme of longer than eight weeks is probably required to ensure hypertrophy and optimum gains in the burn patient (Suman et al 2001)

5.316 Safety Considerations for Strength and Aerobic Training:

Initiating aerobic and strength training:

- studies stipulated a minimum of six months to two years post burn before initiation of programmes, though many subjects were included who had been burned many years before. These participants all benefited from the interventions.
- Suman and Herndon (2007) suggested that the time frame of 6 months post burn was chosen based on clinical experience because by this time paediatric patients with >40% TBSA burns were
  - 95% healed
  - ambulatory
  - had had the opportunity to return home
    - Therefore, more favourable psychological status
- There were no studies investigating early training
  - With extensive burns, adequate healing of wounds and medical stability required before initiating aerobic/strength exercise

Other safety considerations:

- Though exercise has been shown to increase lean body mass, liaison with doctors concerning anabolic steroids and medication and with dieticians regarding optimal nutrition is recommended in order to ensure correct management of hypermetabolisim.
- Caution should be used with regard to impaired thermoregulation. Monitoring of heart rate and blood pressure may be advisable, particularly on initiation of exercise and when exercising with additional thermal stress. Manage the environment to minimise thermal stress initially in particular.
- Particularly those at risk of reduced pulmonary function post burn (i.e., >30% TBSA, injury to torso, or inhalation injury), monitor SpO2 and RPE during exercise. Allow additional rest periods to allow SpO2 to return to normal levels post exercise, as this has been shown to be delayed.

Section 6: Psychosocial Aspects of Burn Patient Rehabilitation

Burn injury is a traumatic event. Burn scars change the cosmetic appearance of an individual and force them to deal with altered body image. The pain of rehabilitation can also lead to a psychopathological response. Depression and post traumatic stress disorder (PTSD) are the most common areas researched in burn patients. It is important as physiotherapists to recognise the risk factors, sign and symptoms, and treatment options for such patients. (Van Loey et al 2003)

6.1 PTSD

Definition PTSD is an anxiety disorder that some people get after seeing or living through a dangerous event. People who have PTSD may feel stressed or frightened even when they're no longer in danger. (WHO 2012)

Prevalence 31-45.2% of burn injured patients

Signs and Symptoms (Ozer et al 2003)

- Re-experiencing symptoms:
  - Flashbacks—reliving the trauma over and over, including physical symptoms like a racing heart or sweating
  - Bad dreams
  - Frightening thoughts.
- Avoidance symptoms:
  - Staying away from places, events, or objects that are reminders
  - Feeling emotionally numb
  - Feeling strong guilt, depression, or worry
  - Losing interest in activities that were enjoyable in the past
  - Having trouble remembering the dangerous event.
- Hyperarousal symptoms:
  - Being easily startled
  - Feeling tense or "on edge"

- Having difficulty sleeping, and/or having angry outbursts

In very young children, these symptoms can include:

- Bedwetting, when they'd learned how to use the toilet before
- Forgetting how or being unable to talk
- Acting out the event during playtime
- Being unusually clingy with a parent or other adult.

Older children and teens usually show symptoms more like those seen in adults. They may also develop disruptive, disrespectful, or destructive behaviours. Older children and teens may feel guilty for not preventing injury or deaths. They may also have thoughts of revenge

<u>Detection and Diagnosis</u>

- Diagnosed by psychiatrist/ psychologist

To be diagnosed with PTSD, a person must have all of the following for at least 1 month:

- At least one re-experiencing symptom
- At least three avoidance symptoms
- At least two hyperarousal symptoms
- Symptoms that make it hard to go about daily life, go to school or work, be with friends, and take care of important tasks. (NIMH 2009)

Who is most at risk of developing PTSD?

Risk factors	**Resilience factors**
• Patients perceptions, • Lack of social support, • High emotional distress, • Maladaptive coping strategies, • Pre-existing anxiety/depressive disorders, • History of past exposure to traumatic events, • Anxiety related to pain, • Facial/hand injury, • Female, • Additional stress due to loss of loved one/job/home	• Seeking out support from other people, such as friends and family • Finding a support group after a traumatic event • Feeling good about one's own actions in the face of danger • Having a coping strategy, or a way of getting through the bad event and learning from it • Being able to act and respond effectively despite feeling fear. (Brewin et al 2000)

Table 14: risk and resilience factors of PTSD

Treatment

The main treatments for people with PTSD are psychotherapy ("talk" therapy), medications, or both. (NIMH 2009)

6.2 Depression

Definition

Depression is a common mental disorder, characterized by sadness, loss of interest or pleasure, feelings of guilt or low self-worth, disturbed sleep or appetite, feelings of tiredness and poor concentration. It can be long lasting or recurrent, substantially impairing a person's ability to function at work or school, or cope with daily life. At its most severe, depression can lead to suicide. (WHO 2012)

Prevalence

Estimates of rates of depression vary widely due to variety of assessment instruments, cut-off points and small sample sizes. Reports of prevalence of depression in the first 12 months range from 25-65% and 12 months post burn vary from 18-34%.

Risk factors (Van Loey 2003)

Death of a loved one, destruction of property, loss of bodily integrity, pain, social isolation during hospital stay, pre-morbid affective state, female plus facial disfigurement

- Pre-burn individual variables (premorbid psychiatric history, employment status at the time of the burn, female gender, trait anxiety, personality);
- Burn-related variables (burn size and severity, burn visibility, location of the burn, dissatisfaction with body image, pain, physical function); and
- Resilience-recovery variables (social support, compensation seeking, and coping strategies).
- External stressors (loss of a loved one, destruction of property, job loss)

Treatment

Psychosocial intervention first line of treatment, antidepressants if required.

Social problems

- The publics' reaction to their scars (NB for facially disfigured people)
- Reported reactions from the public: naked stares, startle reactions, remarks, personal questions, avoidant behaviour towards them

- Difficulties in meeting new people, making friends and developing intimate relationships
- The complex mixture of feelings and thoughts and behaviours of the facially disfigured person is summarized in the acronym SCARED "self-conscious, conspicuous, anxious, rejected, embarrassed, and different. This may induce negative attitude and beliefs which are expressed in the burn patients behaviour
- Psychosocial problems: demoralisation, social isolation, loneliness, bereavement related to disfigurement. Can lead to social death.
- Feelings of loneliness prevalent in 1 in 4, 30% reported a solitary lifestyle 1-2 yrs post burn

  Sexual problems are prevalent, particularly in females, due to alterations in appearance, low self esteem and loss of sensitivity in burned skin. (Van Loey 2003)
- Social anxiety not reported to be a significant problem 1 year post burn
- People with burn scars tend to avoid certain social situations e.g. swimming pool
    - This may influence their capacity to participate in functional rehabilitation.

<u>Return to work</u>

Cohort study of 154 hospitalised major burn patients with telephone interviews up to one year post burn

- 79.7% returned to work one year post burn
- Issues identified
    - Physical and wound issues
    - Environmental(work conditions: temperature, humidity, safety)
    - Psychosocial barriers as above

There is evidence that workplace accommodations does decrease the duration of disability. In the early follow-up periods, the social abilities category had a low impact rating of approximately 2.0, and this increased significantly to approximately 6.0 at the last follow-up.

- In those people with prolonged disability, psychosocial factors were an important factor preventing them from returning to work.

    - Further review of the data shows very high rates of psychological issues such as nightmares or flashbacks, concern over appearance, and depressed mood preventing return to work.
    - Other studies have shown the role of depression in predicting return to work.
- Over 30% of subjects with burn injuries have longer-term disabilities.

Treatments

- Few studies of psychological treatments
    - CBT
    - Pharmacological Rx (selective serotonin reuptake inhibitors)
    - Exposure therapy
    - Eye movement reprocessing and desensitisation
    - Psychological debriefing
    - Social skills training and community intervention
    - Sexual health promotion and counselling
    - Vocational rehabilitation

6.3 Psychosocial Issues and the Clinician:

Studies carried out suggest health care professionals (HCPs) are at risk of developing secondary traumatic stress reactions as a result of working with individuals who have survived traumatic events, and exposure to traumatic material (Elwood et al 2011). This stress reaction is thought to be associated with the HCPs desire to help the survivor. In the literature, many terms have been used to describe this reaction. These include:

6.31 Secondary traumatic stress disorder:

"The natural consequent behaviours and emotions resulting from knowing about a traumatic event experienced by a significant other ...resulting from helping or wanting to help a traumatised or suffering person". The effects of this are threefold:

- Psychological distress/dysfunction: distressing emotions, intrusive imagery, numbing, avoidance

- Cognitive shifts: alterations in the clinician viewpoint in dependence/trust in others, sense of safety/vulnerability, feelings of power/helplessness and independence or a loss of control
- Relational disturbances: alteration in both personal and professional relationships e.g. distancing emotionally or over-identification with trauma survivors

Vicarious traumatisation: "the cumulative effect…of working with survivors of traumatic life events"

6.32 Burnout

Differs from these as the definition, as it clearly defines the domains of change, referring to "physical, emotional and mental exhaustion" one expects to find following prolonged "involvement in emotionally demanding situations". These results in symptoms in the areas associated with secondary traumatic stress disorder, as well as in work and interpersonal symptoms.

6.33 Compassion fatigue: results from "the exposure of helpers to experiences of patients, in tandem with the empathy they experience for their patients". This shift is thought to be sudden and acute in onset, whereas burnout is a gradual process

While there are subtle differences between the definitions, these terms are often used interchangeable to describe the PTSD-like symptoms of secondary traumatisation.

(Collins and Long 2003; Elwood et al 2011)

Presence and severity

Studies have reported varying levels of severity and prevalence.

The nature of burns injuries is often traumatic event and as there is a lack of psychological services in Ireland, the role is often passed to other members of the MDT. As physiotherapists we are exposed to large periods of time with the patient and as the patient-clinician relationship develops, we can be exposed to accounts of the incident or other traumatic material.

The variations in the severity of secondary traumatic stress are somewhat related to the lack of an accurate measurement tool (Elwood et al 2011). It has been suggested that secondary trauma is related to individual characteristics such as age, gender, and environmental factors, training and supervision (Elwood et al 2011).

Trauma related therapy exposure and reactions:

This is difficult to assess clinically. Studies have however, made the association between the amount of hours spent working with trauma clients and i) trauma-related symptoms, without cognitive alterations, ii) burnout, iii) depersonalisation and iv) trauma symptoms. This association does not allow for prediction of secondary traumatic stress.

Increased symptom severity is associated with shorter time treating patients in that area. Individuals who suffer the most severe symptoms are more likely to leave that area of work. The outcome of therapy and the reward of participating in therapy may be a protective factor for the development of secondary traumatic stress (Elwood et al 2011).

Personal trauma history: There is conflicting research but history of personal trauma may a predictive factor for the development of secondary traumatic stress, with studies both supporting and negating the argument. (Elwood et al 2011).

Current research:

- Lack of clarity over definition of what exactly is a normal and abnormal stress response.
- Samples included in studies: lack of group comparison to identify whether this phenomenon is exclusive to populations of clinicians that deal with trauma survivors.
- Measurement tools: clarification of assessment periods, both time since exposure and the time period the assessment tools assess. Tools to date assess the presence of symptoms, not addressing the clinical implications of these symptoms, and their functional impact. Use of scales such as Impact of Event Scale (IES) which is used to assess PTSD in survivors, questions arises over the sensitivity of the scale to assess secondary traumatic stress.
- More complex statistical analysis of the data e.g. structural equations modelling or hierarchical linear modelling. (Elwood et al 2011)

6.34 What can we do to protect ourselves?

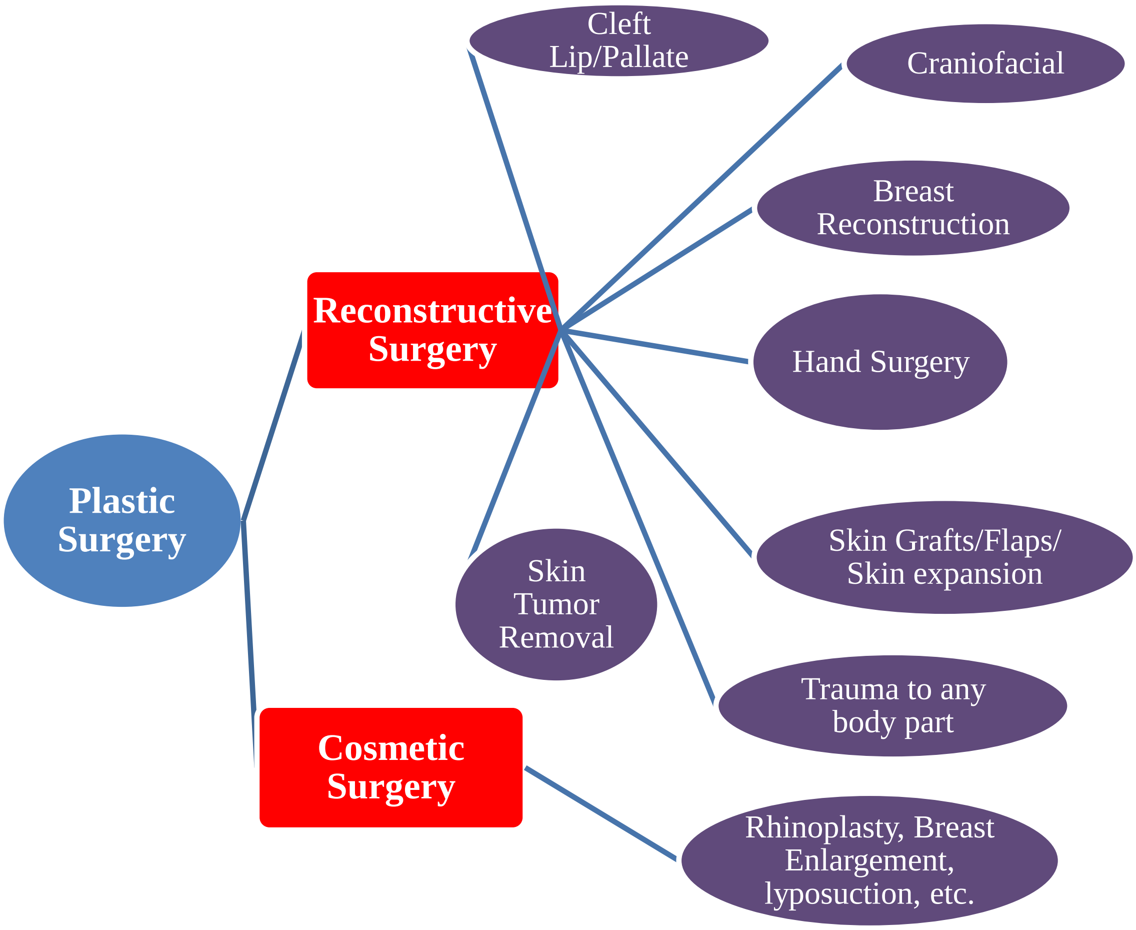
- Adequate self-care: monitor changes in trauma-related schemata (safety, trust, control, esteem and intimacy) and balancing personal and professional activities.
- Workplace interventions include: limited caseload, trauma specific supervision, increasing staff support time, increasing clinician leave and providing opportunities to receive mental health services and online support. Greater understanding of clinically relevant levels of secondary trauma symptoms is needed however, before implementation of costly interventions.

(Elwood et al 2011)

Part 2:
Physiotherapy in Reconstructive Surgery

Section 1: Introduction

Plastic Surgery: The word ‘plastic’ comes from the Greek word ‘plastikos’ meaning to mould or to sculpt: therefore, plastic surgery refers to procedures which involve moulding or sculpting tissues to achieve reconstruction or cosmetic effect (Irish Association of Plastic



Surgeons 2012).It consists of two aspects: reconstructive and cosmetic surgery.

Figure 24 Reconstructive and Cosmetic Surgery, (IAPS 2012)

Reconstructive Surgery: Performed on **abnormal** structures of the body to improve function or approximate normal appearance. Abnormalities may stem from

- Congenital defects/ Developmental abnormalities
- Trauma/Disease/Infection/Tumours

Cosmetic Surgery: Performed on **normal** structures of the body to improve appearance. (American Society of Plastic Surgeons, 2012)

1.1 General Principles of Reconstructive Surgery:

Standard physiotherapy protocols are available for many of the most common reconstructive and orthopaedic surgeries, such as ACL repair, breast reconstruction and carpal tunnel release. However, the availability of specific protocols for less common surgeries is limited. Thus, the rehabilitation programme is based on the clinical experience and judgement of the physiotherapist, and consultation with the surgeon.

In this section we hope to outline the principles used in physiotherapy protocols, and address our need, as clinicians, to devise such a programme. These principles are all adapted from the standard physiotherapy protocols for: ACL reconstruction, Meniscal repair, Achilles tendon repair, rotator cuff repair, breast reconstructive surgery, carpal tunnel release and ulnar decompression (Cappagh National Orthopaedic Hospital 2012, Guy's and St. Thomas' NHS Foundation Trust 2012)

1 Pre-op requirements:

Prior to surgery the PT should carry out an assessment of and treatment where indicated:

- Range of Motion (ROM)
- Muscle strength
- Mobility status
- General functional ability
- Respiratory assessment
- Pre-op exercise programme
- Sensory component (for nerve involvement)
- Education: regarding the post-op rehabilitation process, answering patient questions and concerns

2 What structures are being repaired?

- Contractile v. Non-contractile tissues
- Healing times for various tissues
- The level of damage to be repaired should be noted pre-op as this will potentially alter the surgical and rehabilitation protocols.

3 Does the repair need to be immobilised?

- Duration of daily immobilisation
- Mode of immobilisation: cast or removable splint
- Weight bearing status
- Position of immobilisation to unload the repaired structure v. Sustained stretch of the repaired structure
- Elevation to minimise swelling
- Positioning a to encourage full ROM

4 When and how should mobilisation be introduced?

- Strengthening: specific to the impaired structures and general to the limb/body
- ROM: passive and active
- Flexibility: of the soft tissues and scar
- Proprioception: to minimise risk of re-injury and return to higher level activity/sport
- Circulatory exercises (anti-DVT exercises)
- Mobility and balance
- Postural exercises
- Donor site

Exercise prescription is continuous throughout the period of rehabilitation and must be regularly prescribed and revised:

- Immobilisation/mobilisation
- Non-weight-bearing/weight-bearing
- Discharge from inpatient care and home exercise programme (HEP)
- Prior to return to activity and higher level functions

5 What stage of rehabilitation is this patient at?

This refers to the progression of the rehabilitation process. Clinically, the stage of the rehabilitation process, at which we treat the patient, may be dependent on our clinical setting. In the acute setting we will see patients' pre and post op, whereas in the primary care setting the patients will present at any stage from 2-6 weeks post operatively. The stages of rehabilitation are largely dependent on the healing process and the structure being repaired. Rehabilitation begins with the pre-op assessment and prescription of advice and exercise, and follows through to the patients return to normal activity, including higher level of functions (including sport participation). What the clinician needs to be aware of:

- The healing process of the repaired structure
- The requirements of the repair pre-discharge from hospital and outpatient physiotherapy
- The goals of the rehabilitation process
- Safety precautions

6 What does the patient need to be educated about?

Patient education is essential throughout the entire rehabilitation process to optimise patient outcomes. Education encompasses:

- Safety precautions to consider, e.g. ROM and weight bearing, return to previous function
- What the rehabilitation process involves
- Pain relief
- The clinical reasoning behind each component of the rehabilitation programme
- Wound care and hygiene
- Advice regarding return to normal activities, such as work and driving
- Return to sport
- Possible complications following repair, and what, if anything, needs to be monitored
- What the patient can do to aid rehabilitation, e.g. massage to scars, exposure of the scar area to different textures for altered sensation

1.2 : Reconstructive Surgery of the Hand

Hand surgery may be undertaken by either a Plastic Surgeon or an Orthopaedic Hand Surgeon (IAPS 2012). Hand surgery consists of those conducted on the hand, wrist or nerves of the upper limb (IAPS 2012). Examples include

- Congenital abnormalities
- Flexor/Extensor tendon rupture
- Peripheral nerve damage
- Carpal tunnel syndrome
- Conditions of the wrist and finger tendons e.g.
    - Trigger finger/thumb
    - Boutonnieres disease
    - De Quervains Tenosynovitis
- Dupuytrens Contracture
- Amputations
- Arthritis

Tendon Rupture and Repair: These injuries require significant input from physiotherapists in the rehabilitation process. The tendons of the hand pose a particular challenge for the therapist, as full hand function requires the tendon to glide long distances and co-ordinate with many aspects of a complex anatomy (Cooper 2007). Flexor tendon injuries are one of the most common and complex injuries which occur in the hand (Bal et al 2011). One UK hospital found them to account for 5% of all soft tissue injuries presenting over a 5 year period (Clayton and Court-Brown 2008). Flexor tendon repairs pose more of a challenge than extensor tendon repairs because of their more complex anatomy, a higher risk of adhesions and complications, and the higher demands placed on the flexor tendons by ADLs (Cooper 2007). They have significant functional implications both in the short and long term (Bal et al 2011). As they typically occur in a young, active population (mean age 33-38.7 yrs.) they have a huge impact on daily activities (Clayton and Court Brown 2008). As such, skilled functional rehabilitation and an in depth understanding of the injury and anatomy is necessary to optimise outcomes. It is important to remember, however, that although the following sections are dedicated to tendon repair, most of the concepts covered are highly transferrable, both to other reconstructive surgeries and general soft tissue and orthopaedic injuries.

1.3 Anatomy of the Hand

The flexors of the fingers are flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP).

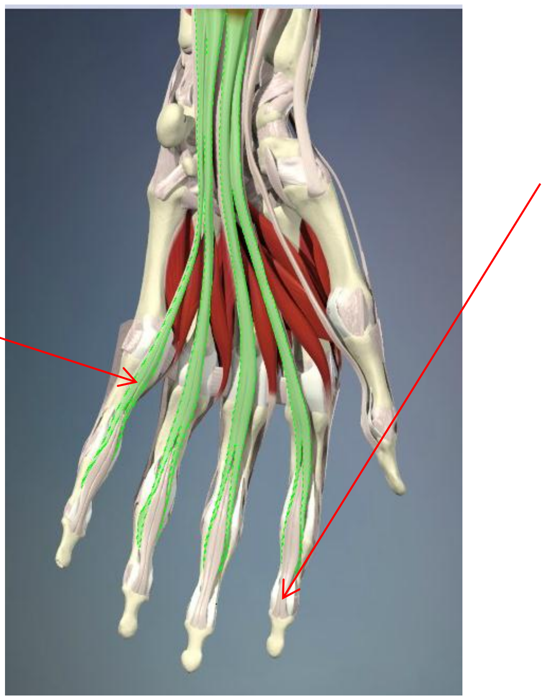
Figure 25 Flexor Digitorum Profundus (UW medicine, 2012).

Arising from the upper ¾ of the ulna, the muscle passes distally. The tendon of the index finger separates in the forearm, with the rest remaining a common tendon until they pass into the palm. (Sinnatamby 2006)

Figure 26 Flexor Digitorum Superficialis (UW medicine, 2012).

The FDS arises from two heads (humeroulnar and radial). As the muscle passes distally, it begins to diverge into an intermediate tendon from which the distal tendons arise. (Sinnatamby 2006)

At the base of each middle phalanx, each tendon of the FDS bifurcates into two slips. These pass dorsal to the FDP and insert into the base of the palmar surface of the middle phalanx. (Sinnatamby 2006)



FDP passes into fingers deep to FDS, through the fibrous passage formed by the two slips of FDS, to insert at the base of the distal phalanx (Sinnatamby 2006)

Figure 27 Insertion of the tendons of FDS and FDP. (Anatomy TV 2012)

Fibrous sheaths: tendons to each phalanx are surrounded in a strong fibrous sheath: tendons of both FDP and FDS are enclosed in this sheath on each finger. Thickenings in this sheath form the pulley system (see figure ?) (Sinnatamby 2006)

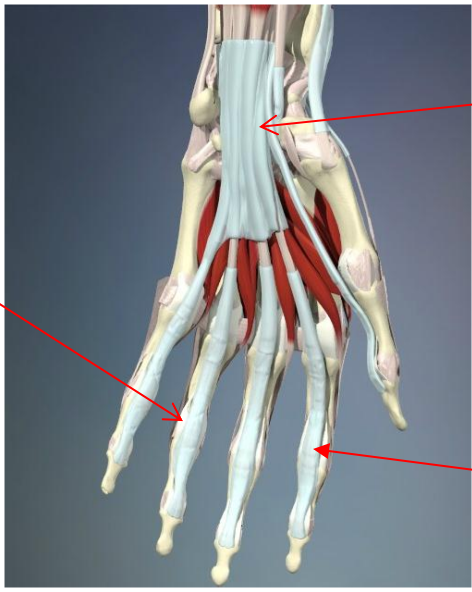


Figure 28 synovial/fibrous sheaths of the flexor tendons. (Anatomy TV 2013)

Flexor Sheath: All tendons of FDP and FDS are enclosed in a common synovial sheath passing through the carpal tunnel (Sinnatamby 2006)

The sheath contains synovial like fluid, which both aids in gliding, and is a source of nutrition for the tendon. Respect for the sheath during repair is necessary to optimise healing. (Sharma and Maffulli 2005)

A1 and A3: may be lost without loss of function in the hand. (Anatomy TV, 2013)

A2 is the most important pulley biomechanically. If lost, flexion to palm cannot be achieved, and bowstringing of the tendon will occur.

A4 is the second most important. Without either of these tendons, finger to palm flexion cannot be achieved. (Anatomy TV, 2013)

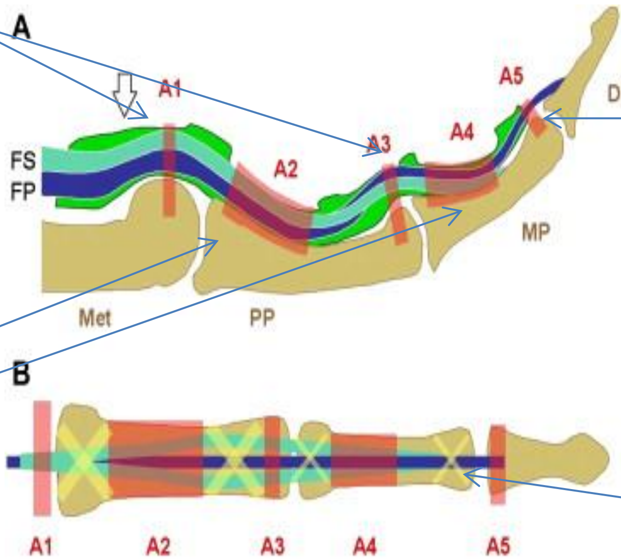


Figure 29 the pulley system. (Bianchia et al, 2007)

A5: loss of this pulley will not result in loss of finger to palm flexion, but it will be difficult to maintain DIP/PIP flexion. (Anatomy TV, 2013)

C1-3: lie between A pulleys. May be expended without loss of function. (Anatomy TV, 2013)

Pulleys are thickenings of the above fibrous sheath which serve to hold the tendon against the phalanx for effective flexion. They also aid gliding through their synovial lining Annular (A) pulleys consist of arcuate fibres and are strong and inflexible. Cruciform (C) pulleys are thinner and more lax, and allow some pliability. (Strickland 2005)

1.31 Zones of Injury

Flexor tendon injuries are classified by the location at which they occur. The zone of injury has significant implications for management, rehabilitation and prognosis.

Zone I:

- Mid-middle phalanx- Insertion of FDP
- Contains pulleys A4, A5 and C3

Zone II:

- No Mans' Land
- Transverse crease of hand- Mid-middle phalanx
- FDS and FDP travel within fibrous sheath
  - FDS bifurcates
  - Passes dorsally to FDP.
- Contains
  - digital nerves in close proximity to tendons
  - Pulleys A1, A2, A3, C1 and C2

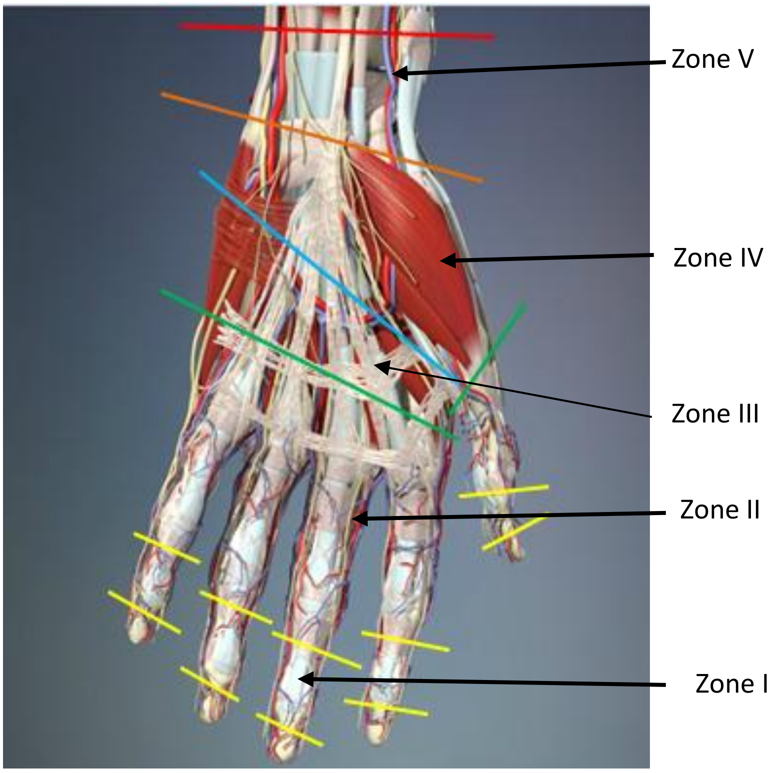


Figure 30 Hand Anatomy, (Anatomy TV 2012) with Flexor Tendon Zones of Injury (Radsource 2009)

Zone III:

- Base of palm- transverse crease of palm
  - Tendons not contained in the fibrous sheath
- Contains lumbricals

Zone IV:

- Carpal Tunnel: Contains median nerve

Zone V

- Carpal tunnel- Musculotendinous junction of flexor tendons in the forearm
- Contains ulnar and median nerve, radial and ulnar artery.

(Duke Orthopaedics 2009)

1.4 Tendon Healing

Though tendons heal according to the same processes of other tissues in the body, their unique vascularity predisposes them to certain modifications of the process.

1) Intrinsic Vascularity:
    - Blood supply enters the tendon directly from the myotendinous and osteotendinous junction
    - Supplies proximal 1/3 of tendon, and a small area around the insertion to the bone
2) Extrinsic Vascularity
    - Blood vessel plexus forms between the sheath and the tendon

- Vascularity varies along the length of the tendon
    - Areas may be quite hypovascular as healthy tendons require 7.5 times less O2 than muscle tissue
- Low metabolic rate may slow the healing process

(Sharma and Maffuli 2005)

1.41 Healing types:

Extrinsic: Dependent on the formation of adhesions with surrounding tissues to provide blood supply and cells required for healing

- Disruption of synovial sheath during injury or repair allows the infiltration of granulation tissue from surrounding structures
- Implications for clinical outcome as adhesions limit gliding and function.

Intrinsic: occurs between the two ends of the severed tendon

- No requirement for adhesions
- Internal tenocytes contribute to repair
    - Secrete large amounts of mature collagen
- Improved biomechanics post injury

(Sharma and Maffuli 2005; Strickland 2005)

Both types of healing contribute at different stages in the healing process. However, the relative contribution of extrinsic healing, and adhesion formation is increased by:

- Trauma to tendon sheath from injury/surgery
- Tendon ischemia
- Tendon immobilisation
- Gapping at the repair site
- Excision of components from the tendon sheath during repair (Strickland 2005)

Table 15: Stages of Tendon Healing (Cooper 2007; Sharma and Maffuli 2005; Strickland 2005)			
Stage	**Timescale**	**Process**	**Tensile strength**
Inflammatory	0-5 days	Influx of inflammatory mediators, phagocytes and macrophages = phagocytosis of debris, increased vascular permeability, initiation of angiogenesis and tenocyte proliferation	That which is imparted by the suture itself. Some contribution from fibrin/clot
Proliferation	4 days-7/8 weeks	Type III collagen production peaks. Water content remains high. Collagen laid down in a haphazard fashion.	Gains tensile strength rapidly increasing, but remains quite weak
Remodelling a)consolidation	6-10 weeks	Repair tissue changes from cellular to fibrous tissue. Change from type III to type I collagen. Tenocyte metabolism remains high. Collagen begins to be laid down along the lines of stress	
b)remodelling	10-12 weeks	Change from fibrous tissue to scar like tendon tissue. Continues up to 1 yr.	Returned close to full tensile strength

1.42 Extensor Tendon Repair

Extensor tendon injury may occur to the extensor digitorum, the extensor digiti minimi, or extensor pollicis longus. The zones of injury vary slightly, and the tendon sheath is less complex than that of the flexor tendons. However, the above information applies to the rehabilitation of these tendon injuries. For an excellent introduction to the specifics of extensor tendon anatomy and rehabilitation, please see Cooper 2007. Extensor tendon repairs may return to normal function at 6-8 weeks, as ADLs place less resistive force on the extensor tendons than they do the flexor tendons (Cooper 2007)

Section 2: Management of Flexor Tendon Injury

2.1 Diagnosis

In many environments, for example, pitch side, private practice etc it may be the responsibility of the physiotherapist to diagnose potential flexor tendon injury. The misdiagnosis of a tendon injury can result in the window of opportunity for repair being missed. Injury to a flexor tendon may be by open or closed means (Cooper 2007).

2.11 Open flexor tendon laceration

Open lacerations most often occur from a sharp object cutting externally, deep enough to include the tendon. Occasionally an injury that causes a bone to be forced through the tendon and skin as it fractures (Klein 2003). Typically open tendon injuries are diagnosed at the time of injury as the wound is explored for tendon, nerve and ligament damage (Copper 2007).

2.12 Closed flexor tendon injury

1) Partial closed laceration: This is the most commonly misdiagnosed form of injury (Klein 2003). The patient may apparently have full ROM, but pain when attempting to use the tendon against resistance. This in addition to the mechanism of injury may indicate partial laceration of a tendon. Consequences of partial closed laceration can include delayed complete rupture, scarring, weakness, adhesion formation and trigger finger (Mackin *et al* 2002).

2) Full closed laceration "Missed finger"

An isolated flexor digitorum superficialis tendon injury with an intact flexor digitorum profundus tendon. This produces a change in the overall finger posture at the proximal interphalangeal joint and an inability to perform flexion at the proximal interphalangeal joint only.

A flexor digitorum profundus avulsion injury is another form of full closed laceration which can occur. This results in an inability to perform distal interphalangeal joint flexion.

Closed lacerations are often overlooked by the patient who doesn't present for medical consultation until the window of opportunity for best treatment has passed. On presentation a clinician must thoroughly examine isolated flexion at the proximal interphalangeal joint and the distal interpalangeal joint in order to avoiding a miss diagnosis (Copper 2007).

2.2 Surgical Management of Flexor Tendon Injuries

Kirchmayr performed the first flexor tendon repair in 1917, several methods have since been established with a 70 – 90% success rates for repairs (Griffin et al 2012).
Maximum exposure of the tendon is essential to guarantee a good repair; the surgeon must preserve vascularity and not cause contractures.

Griffin et al (2012) suggests that the perfect tendon repair should have;

- minimal or no gapping at the repair site,
- minimal interference with the vascularity,
- smooth junction of tendon end, have secure suture knots and
- enough strength for healing. The strength of the repair depends on the type, number and location of loops that the surgeon uses and the type of suture material.

A simple flexor tendon repair takes 45-60 minutes. Complex surgery for more severe injuries could take much longer.

(Griffin et al 2012) (Strickland 2005)

2.21 Primary Repair

- Primary repair is generally performed within 48 hours of injury. It contains a core suture with a circumferential stitch. It would not be possible to do a primary repair 3 weeks post injury due to swelling and contracture at the proximal tendon and muscle fibrosis.
- Results in greater functional outcomes than secondary repair or tendon graft surgeries.
    - A mid-lateral incision or a zig- zag incision is performed.
    - Neurovascular bundles are detected and protected.
    - Both pulleys and membranous portions of the sheath are left intact as further incisions are made on the outer surface of the flexor sheath. To ensure maximum exposure, the skin flaps are maximally retracted.
    - The tendon is grasped by a fine toothed forceps and it is 'milked' proximal to distal.
    - Sutures are placed to secure the tendon to a catheter, where by the surgeon can now distally pull the proximal tendon to repair it.

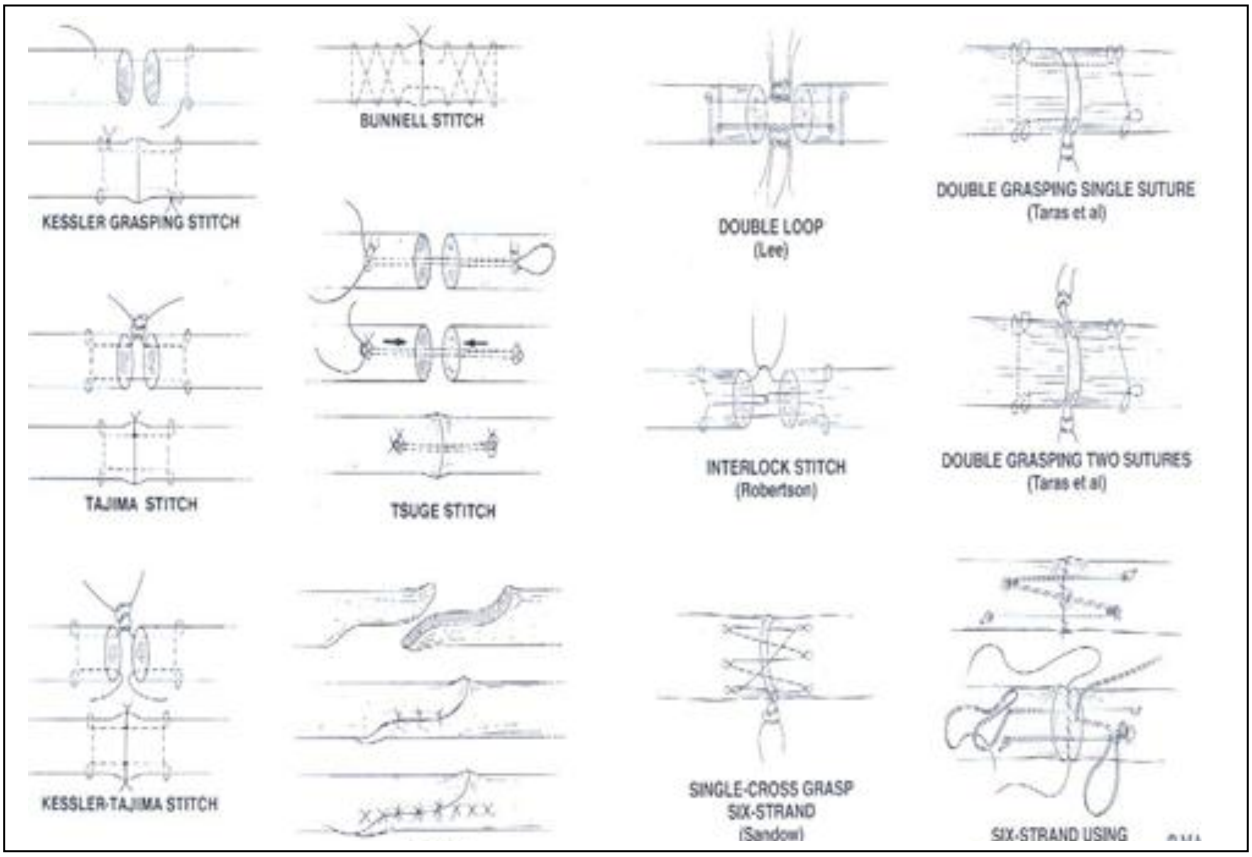
2.22 Secondary Repair.

Secondary repair is used for tendons that cannot be repaired via primary repair. It may be used as a result of increased risk of infections or large losses of soft tissue or if a tendon ruptured. It is a 2 stage tendon graft (e.g. Palmaris longus) with a silicone rod to maintain space within the sheath to maintain ROM. (Griffin et al 2012; Elliot 2002; Strickland 2005)

2.23 Type of sutures and Techniques used

The tendon repair involves both core and peripheral sutures which enhance the strength of the repair. 4/6/8 strand techniques are used today. Multi strand techniques show improved strength and gap resistance when early mobilisation is started. These multi strand techniques are challenging and increases the risk of damage to the tendon due to increased handling. Dorsal placement instead of volar placement of the sutures, have been shown to increase strength of the suture 2 - 4 fold. The material used for the suture must be easy to use adaptable, non-absorbable, avoid gap formation, while still preserving its tensile elements until the repair has achieved strength. Materials used include: monofilament, nylon, monofilament polypropylene and braided polyester. The sutures used the primary repair are the circumferential sutures and they were used to make the repair appear more neat and tidy, today they also have shown to improve the force of the repair and the gap resistance by 10 – 50% ((Strickland 2005; Griffin et al 2012).

Fig 31: The most common techniques used are



2.24 Complications of a Flexor Tendon Repair

Immediately post-surgery, complications may include;

- Wound infection. Wound infection rates are relatively low due to prophactically antibiotics given post-surgery.
- Tendon/pulley rupture. . A rupture is most likely to occur between the 7th and 10th day post-surgery as repairs are at its weakest during these days. Rupture of the tendon can occur due to over loading the tendon, oedema, misuse of the hand or bulky tendons. A rupture is seen if there is a gap and this weakens the tendon and increases the length. A rupture is the worst complication as urgent surgery is necessary. Rupture occurs in 3 -9% of cases. A rupture must be immediately treated as it has to be resected. In order to restore active flexion, tendon grafting or staged tendon reconstruction will be carried out. If either of these fail, amputation of the finger may be considered, especially when the neurovascular structures are compromised. (Griffin et al 2012; Johnson et al 2007)
- Poor tendon gliding. The most common complication of a flexor tendon repair is the formation of adhesions which causes stiff joints. Adhesions arise due to trauma to the tendon and sheath, foreign material and / or bleeding in the tendon or sheath, ischemia, digital immobilisation, loss of a tendon sheath or pulley, gap formation following a repair and prolonged oedema. They are formed by the combination of the wound in the flexor tendon and the wound in the sheath during healing. They can also occur in spite of appropriate physiotherapy treatment and can also contribute to an increased rate of ruptured tendons. Up to 20% of patients will get adhesions and will require tenolysis or tendon grafts. Tenolysis is a way of liberating the adhesion around the tendon. It is carried out 3 -6 months post initial surgery.
- Bowstringing of the tendon can decrease the functional outcome post-surgery. If the A2 and A4 pulleys are lost during trauma/ surgery, then there will be a mechanical inadequacy as the flexor tendon bowstrings across the interphalangeal metacarpophalangeal joint. This will result in weakness. Pulley reconstruction is necessary for bowstring treatment.
- Stiffness and joint contractures are common post-surgery. Swan neck deformities occur in patients with a hyper extensible PIP joint. Early rehabilitation through appropriate protocols must be carried out to prevent these.

(Griffin et al 2012; Johnson et al 2007)

2.25 Sheath Repair

Flexor tendon sheath repair is a controversial debate. Conflicting evidence questions whether there is a need to carry out this surgery at all.

Reported disadvantages;

- Tendon gliding may be hindered by reducing the width of the sheath in the repair.
- The sheath may disappear and contribute to poor tendon healing, and that there is little evidence to show that it is successful in improving tendon gliding function.

Reported advantages suggest that;

- it acts as a barrier to adhesion formation,
- stimulates a faster return of synovial nutrition and
- Provides great tendon sheath biomechanics.

(Griffin et al 2012; Khanna et al 2009)

Section 3: Physiotherapy Management

3.1 Post-Operative Flexor Tendon Assessment

Only with an accurate assessment can a physiotherapist clinically reason adjustments to the rehabilitation protocol and give a reasoned prognosis to the patient. Both the subjective and objective assessment of a flexor tendon repair follows a very similar format as any other musculoskeletal assessment of a hand injury. There are however some specifics, outlined below which should be taken into consideration.

3.11 Database/Subjective Assessment

Surgical Note

The surgical note found in the patient's medical chart contains vital information which may have an impact on both the patients overall prognosis and their rehabilitation process. Information a physiotherapist should identify from the surgical note include:

- Date of surgery intervention (Acute or Delayed repair)
- Tendon(s) involved
- Zone of Repair
- Type of repair, type of sutures, number of strands
- Retracted tendon present/ragged or clean cut
- Infection present
- Associated nerve or vascular injury
- Associated skeletal/joint injury (Seiler 2002)

3.22 Objective Assessment

3.221 Observation

- Dressings insitu
- Vascular Status: temperature, skin colour, pulse, circulation
- Skin Condition/Scar Condition/ Sensation
- Soft tissue atrophy/ Strength
- Resting posture of hand

- Willingness to move and ROM
- Oedema

A suggestion for a layout of a flexor tendon specific objective assessment form can be found on page ** of the appendices.

3.222 AROM/PROM

Active and passive ranges are considered a definable and measurable entity, and so are one of the frequently used outcome measure (Ellis and Bruton, 2002). It is also the area of most notable deficit following FTR. Range can be assessed using visualisation, goniometry, composite finger flexion, and wire tracing.

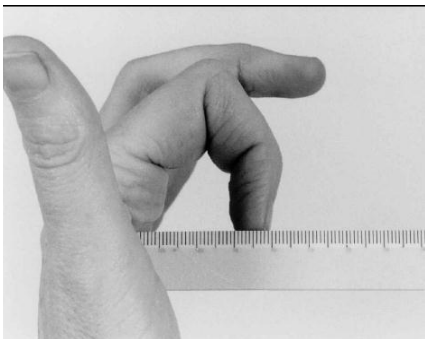


Figure 32 composite finger flexion. Measured from the distal palmar crease to the tip of the finger of interest. (Ellis and Bruton 2002)

Ellis and Bruton (2002) found that

- 76% of 51 physiotherapists and occupational therapists used goniometry most frequently to measure finger ROM, in a population not specific to flexor tendon repair.
- Composite finger flexion was used by 69%.

However, the reliability of these methods had been poorly investigated. Studies of reliability compare different methods of measurement to one another, rather than comparing to a gold standard, of which there is none.

Figure 33 Hand goniometry. Different sized goniometers may be used for different joints. (USneruological 2013)

Ellis and Bruton (2002) compared the reliability of goniometry with composite finger flexion

- 51 PTs/OTs measured a single patient with the finger splinted with goniometry/composite finger flexion
- Each therapist was randomly assigned to carry out one test first, then the other.
- Inter rater
    - Goniometric measures fell within 7-9 degrees of one another.

    - Composite finger flexion falls between 7-9mm of one another.
    - The authors classed this as both measurements having equal inter rater reliability.
- The intra rater reliability
    - Goniometric measures fell within 4-5 degrees of one another.
    - Composite finger flexion measurements differing between 5-6 mm.

Limitations: Patient was splinted in a position may have changed the testers' technique, and is not representative of how the measurements are made in reality. Further statistical tests could also have given a clearer indication of reliability, rather than comparing the variation in two different units.

Ellis and Bruton (1997) compared the reliability of goniometry and wire tracing. Only the abstract of this article could be obtained. They found that goniometry showed greater intra rater and inter rater reliability than wire tracing, in a population of 20 physiotherapists, again measuring a patient fixed in place.

Though there is poor evidence for the reliability of ROM measurements, goniometry seems to produce the most reliable results, and is the measurement most frequently used. Composite finger flexion may be used if a quicker method of assessment is necessary. Patients should be positioned correctly to reduce risk of influencing results (Libbrecht et al, 2006)

Figure 34 measuring power grip. (Mobility smart 2012)

3.223 Strength

Grip strength, lateral pinch, and pincer grip are important functional measures for the hand (Boscheinen-Morrin and Connolly 2001). Strength should not be assessed in a flexor tendon patient until the initial twelve weeks of rehabilitation have taken place as these movements place a large amount of resistance through the flexor tendons. Equipment such as the Jamar dynamometer is required to assess these parameters. The Jamar dynamometer is considered the gold standard tool in assessing hand grip strength (Roberts et al 2010).

Figure35 measuring pinch grip (Kryger 2013)

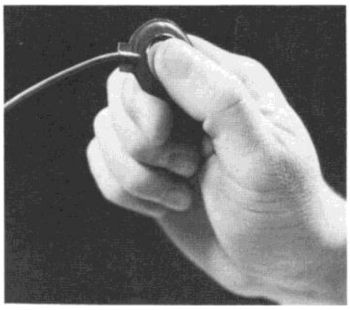


Figure 36 measuring lateral pinch (mobility smart 2012)

3.224 Oedema

Oedema will be present after the surgery. This may simply be assessed using a measuring tape (Boscheinen-Morrin and Connolly 2001). If persistent or fluctuating, using adjuncts such as coban wrap or digisleeves (discussed in the burn section) may need to be considered (Boscheinen-Morrin and Connolly 2001).

3.3 Outcome Measures

Range of motion, pain and strength are essential to functional outcome and therefore, measuring these outcomes, and employing a functional outcome measure, is critical to monitoring and guiding rehabilitation. (Libbrecht et al 2006

3.31 Disability of the Arm, Shoulder and Hand Index (DASH)

The Dash is a tool which facilitates the comparison of conditions throughout the upper extremity while considering the upper extremity as a single functional unit. The psychometric properties of the DASH index are summarised below. Please see the appendices page ** to view the complete Dash outcome measure. (Hudak et al 1996)

Atroshi *et al* (2000)

Title: DASH questionnaire: Reliability and validity evaluation in 176 patients

Subjects: 176 patients (57% female, 43% male Mean age 52) Patients with upper-extremity musculoskeletal conditions planned for surgical treatment or for physical therapy

Outcome measure: DASH questionnaire

Methodology: Completion of questionnaire prior to surgery or rehabilitation. Test-retest reliability, evaluated in a subgroup of 67 patients who completed the DASH on two occasions, with an interval of 7 days

Results: Construct validity was shown by a positive correlation of DASH scores with the SF-12 scores and correlation with the SF-12 physical. The DASH was shown to have excellent reliability and responsiveness to clinical change. Overall the DASH provides a standardised measure of patient-centred outcomes

Limitations: No blinding procedure discussed or randomisation of patients

<u>Section 4: Rehabilitation Post Flexor Tendon Repair</u>

Over time, hand surgeons have discovered, in conjunction with the literature, that strong early repair of a flexor tendon injury combined with early motion therapy programmes produces the best result for the patient (Thien *et al* 2009). In order to come to this thinking, many rehabilitation programmes ranging from strict immobilisation to early/delayed active mobilisation exist and have been researched in depth (Saini *et al* 2010). The following figure shows where the core programmes began and where we are at today.

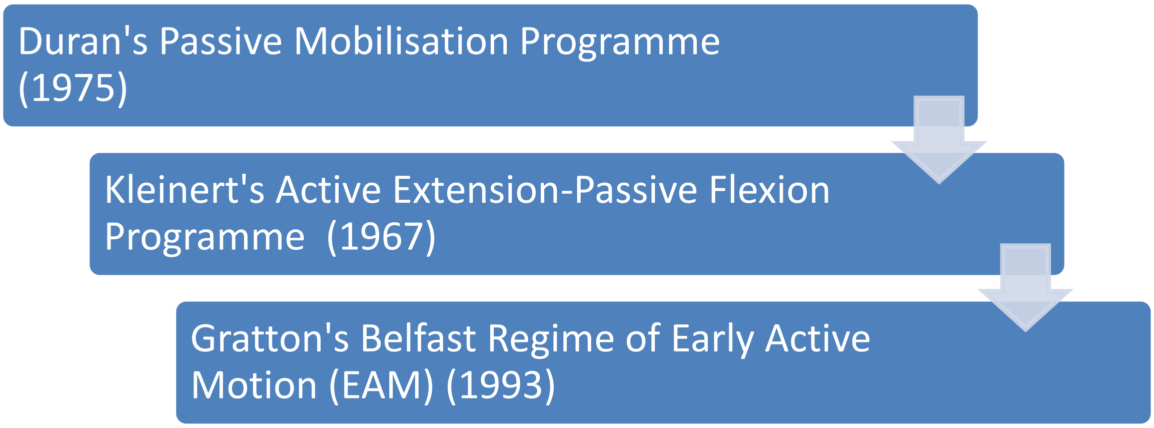


Figure 37 The development of rehabilitation programmes from past to present (Baskies *et al* 2008)

1. <u>Duran's programme (1975)</u> involves careful passive flexion and extension exercises in a dorsal extension block splint for 4 weeks, commenced immediately after the operation. They reported that 3-5mm of passive movement was effective in preventing adhesions (Kitis *et al* 2009).

Figure 38(Pettengill 2005)

Since the introduction of these programmes, many studies have also investigated the effectiveness of programmes which combine both controlled active and controlled passive motion. The ideal method of management in FTR, however, has not yet been clarified (Kitis *et al* 2009).

2. <u>Kleinert's programme (1967)</u> involves active extension-passive flexion mobilisation using a dynamic traction splint. Kleinert's splint holds in 30deg flex MCP's in

Figure 39(Pettengill 2005)

70deg flex and IP's in neutral. A rubber band traction was also places proximal to the wrist crease which allows the finger to attain full active IP extension within the limits of the splint while at the same time retaining its neutral position in flexion (Kitis *et al* 2009).

3. Gratton protocol: Dorsal blocking splint with wrist in 20deg flex, MCP's in 80-90deg flexion and IP's neutral. Every 2-4hours, 2 reps of passive flexion, active extension and active flexion. The aim for the first week is to gain 30deg of active flex for proximal IP joints and 5-10deg for the distal ones. And full finger flexion by the end of the 4th week (Topa *et al* 2011)

Rehabilitation programmes post FTR, with their various individual modifications, generally fit into three main categories:

1. Active extension- passive flexion method
2. Controlled passive motion method
3. Controlled active motion method

There are many variations of these three methods in clinical practice today with each protocol having its merits and demerits (Griffin *et al* 2012; Saini *et al* 2010). Due to the abundance of different protocols available, a physiotherapist must not only know the various protocols but also know when and why it is appropriate to use which one (Topa *et al* 2011).

4.1 Aims of Rehabilitation

"A strong tendon that glides freely" (Saini *et al* 2010)

Post- operatively, rehabilitation aims to strike a balance between protecting the repair from disrupting forces while at the same time preventing adhesions at the site of repair (Thien *et al* 2009). In more recent times early active mobilisation (EAM) has become the most popular. The concept of early mobilisation is believed to be in favour of restoring gliding function, increasing tensile strength, improving tendon excursion and stimulating restoration of the injured tendon (Thien *et al* 2009). At the same time, the rehabilitation process must strive to ensure that the risk of rupture or re-rupture is reduced as much possible (Griffin *et al* 2012).

4.2 Benefits of Rehabilitation

Mobilised tendons have a lot more benefits over immobilised tendons. Mobilised tendons have been shown to:

1. Heal quicker
2. Have fewer adhesions
3. Overcome stiffness
4. Overcome swelling of the digits
5. Promote early return to function
6. Reduce the likelihood of deformity formation (Saini *et al* 2010)

In the past, immobilisation strategies lead to increased disability, weak tensile strength, decreased functional capacity, stiffness and deformity (Saini *et al* 2010).Current practice aims to mobilise tendons early without overloading them too soon after treatment in order to prevent these complications (Thien *et al* 2009).

4.3 Early Mobilisation

Although early mobilisation risks rupture of the repair, the benefits strongly outweigh the risks (Xie *et al* 2008). These benefits have been discussed previous. A study by Xie *et al* (2008) looked at the force of resistance to tendon motion and the work of digital flexion within the first 5 days after repair in chicken models with partial lacerations in Zone II. Chicken models are often used in the research of flexor tendon repair as the tendon structure of their toes is similar to that of human digits. This study showed that resistance to tendon motion increases significantly on days 4-5 and so mobilisation should be commenced at day 4/5.

A study by Saini *et al* (2010) outlined in the table below showed that 82% of 77 repairs showed good to excellent results post early active mobilisation. Outcome in Saini *et al* (2010) was also varied depending on whether the lacerated ends of the tendon were a straight cut or a frayed cut. The tendons with a straight cut tended to show excellent results while the tendons frayed after the cut showed poor results. The table on the following 2 pages is a synopsis of three studies in order to compare three methods of controlled mobilisation post FTR.

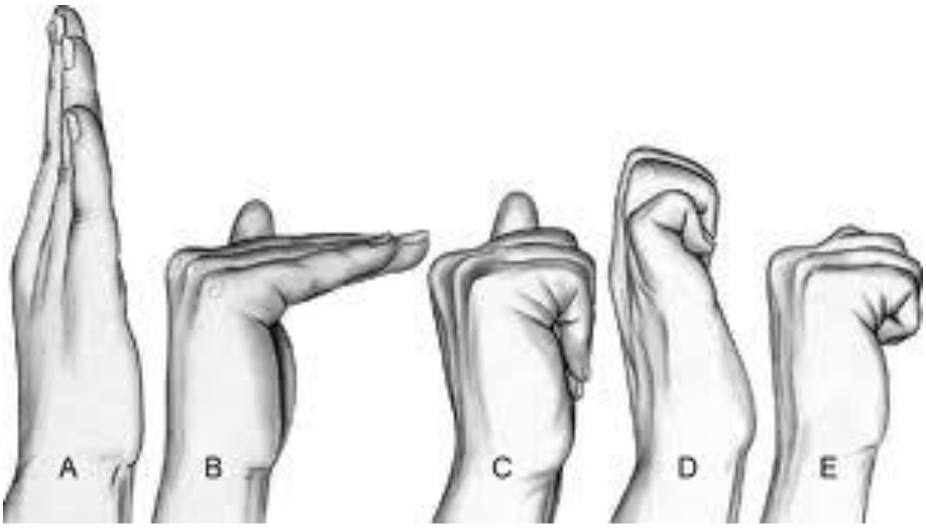


Figure 40 Progression of controlled mobilisation post FTR (Evans 2004)

4.4 Rehabilitation: The Evidence

Article Citation	Yen *et al* (2008)	Saini *et al* 2010	Kitis *et al* 2009
Design	A prospective cohort study. The controls in this study were based on a retrospective analysis.	An experimental study.	
Subjects	10 subjects that were consecutively admitted for acute FT injury in zone II between Oct 2005 and April 2006 were chosen. 7 male and 3 female, mean age of 41 years. Inclusion and exclusion criteria were determined. The control group consisted of age and sex matched patients that had undergone FTR prior to Oct 2005.	25 patients with cut flexor tendons in zones II – V with/without an associated vessel or nerve injury presenting within 7 days of injury. 22 patients had >1 digit involved (75 digits in total). Exclusion criteria outlined. 9 underwent primary repair, 15 underwent delayed primary repair and one had secondary repair.	Jan 2006-June 2008 192 patients(263 fingers) with lacerations of flexor tendon FDS and FDP in zone II. No thumbs. All unilateral injuries. Inclusion and exclusion criteria outlined.
Intervention	Patients in both groups underwent the same flexor repair method. The cohort group underwent early mobilisation with active extension, progressive active and passive flexion and active hold in a dorsal splint with 30deg wrist flexion. The control group followed the rehabilitation regime of Kleinert splintage with palmer bar.	Post-op immobilisation involved a splint in 10-15deg wrist flexion, 70deg flexion of MCP's and IP's in mild flexion. Rehab protocol involved active extension, initial active flexion and later passive flexion. Patients were instructed to not passively stretch the repaired tendons. Rehab protocol lasted 12 weeks.	98 patients treated with Washington regime of controlled movement rehab. 94 patients treated with controlled passive movement programme post operatively. Washington regime of active extension and passive flexion began at days 1-5. The Kleinert splint was used in this group. Instructed to actively extend IP's and passively flex 12 times/hr for first 3 weeks. After this time, the wrist was brought to neutral. At week 5 active wrist ext was introduced and also active finger flexion. At 6 weeks the splint was removed. At 6-8 weeks light functional activities were allowed. At weeks 8-12 resistance was increased. During these 12 weeks, the pt was seen by the therapist 3 times per week. In the passive flex and ext group a dorsal splint was used. 8reps per hour of passive movements for first 5 weeks. During week 5 active movements introduced 10 reps hourly. Splints removed at end of week 5. Reps increased to 12 hourly. Weeks 8-12, progressive strengthening exercises and normal functional activities introduced. Pts seen 3 times weekly by hand therapist for first 12 weeks.
Follow Up	Mean follow up for cohort group was	At 14 weeks was the final Ax and 6 months was	Ranged from 6-20 months

	4months. Mean follow up for control group was 16.5 months.	the functional Ax	
Outcome Measures	Grip strength, pinch strength, ROM and patient satisfaction.	Louisville system	ROM using the Buck-Gramcko system, TAM (total active movement), grip strength, DASH
Statistical Analysis	Paired-samples T-test taking P≤0.05 as statistical significance.		Paired students' t-test
Results	In the cohort group, grip strength, pinch strength and ROM were all 90% of the normal digit. 5 patients reported the surgery as excellent and 5 as good. In the control group, grip strength, pinch strength and ROM were 50%,40% and 40% of the normal side respectively. Patients reported satisfaction as either fair or poor. All results were statistically significant at P≤0.05.	82% excellent to good results, 9% fair and 9% poor post early active mobilisation on the Louisville system.	There was no significant differences between the groups for total active movement (TAM). However, for ROM, significant differences arose between the groups with 87% of the Washington group attaining excellent outcome and 75% of the passive group attaining excellent outcome. No signif difference between the groups for grip strength. The Washington group scored much lower in the DASH than the passive group (P=0.01). There was a signif difference between the groups for IP extension difference with the result in favour of the Washington group (P=0.03). No ruptures in Washington group and one in passive group.
Limitations	Patient compliance with rehab. Difference of 12 months in follow up times between the 2 groups. Only included the four core strand suture repair as surgical technique therefore limits in generalisability. Variation s in demographic details of the age-matched controls. Re-rupture in control could have been due to a number of different factors. Small number of participants.	This study looked at FTR in many different zones, digits and tendons. Therefore, a small sample of many different groups was analysed making it difficult to generalise it to particular populations. Lack of a control group.	Subject selection process was not discussed. Patient compliance to strict exercise regime. Use of an unvalidated OCM-the DASH.

Table 16 A table comparing the methods of controlled mobilisation post flexor tendon repair

4.5 Early Active Motion (EAM) Protocol

Many authors believe that controlled active movement has added advantages over methods of passive motion including fewer adhesions, and better results in terms of flexion deformity and extension deficit (Kitis *et al* 2009). Remarkable clinical results, seen in the table above, were found in the study by Kitis *et al* (2009) for a controlled active and passive motion programme when compared to a programme solely containing passive mobilisation at the early stages of rehabilitation.

There is an abundance of EAM protocols in existence. A study by Topa *et al* (2011) looked at four of the most prevalent EAM protocols in order to aid hand therapists in deciding which one is most adequate in which circumstances. The following is an outline of this prospective study:

Subjects: 94 consecutive patients with primary repaired zone II flexor tendon injuries attending a Plastic and Reconstructive Dept. from May 2008 until Dec 2010.

Methodology: Four different EAM programmes were applied to each patient depending on their entrance time to hospital for FTR. The patients were grouped as follows: 1) May-Dec 2008, Kleinert protocol (20pts) 2) Jan-Aug 2009, Silfverkiold protocol (22pts) 3) Sept 2009-April 2010, Strickland protocol (26pts) and 4) May 2009-Dec 2010, Gratton protocol (26pts). The patients were followed up 8 weeks for treatment and the final evaluation was done at 12 weeks.

The EAM protocols:

1. *Kleinert modified protocol:* wrist in 30deg flex, MCP's in 70deg flex and IP's in neutral. Palmar pulley for traction in situ. 10reps per hour of active extension and passive flexion of the injured finger (see picture in previous section).
2. *Silfverkiold protocol:* wrist in neutral, MCP's in 50-70deg flexion and IP's in neutral. 10 reps per hour of active extension, passive flexion and isometric flexion.
3. *Strickland protocol:* Dorsal blocking splint with wrist in 20deg flexion, MCP's in 50deg flexion. A tenodesis splint which allows full wrist flexion, wrist extension of 30deg and MCP joint flexion of 60deg is used hourly. 15 reps per hour of MCP and IP passive flexion and 25reps of isometric flexion contraction.

4. *Gratton protocol:* Dorsal blocking splint with wrist in 20deg flex, MP's in 80-90deg flexion and IP's neutral. Every 2-4hours, 2 reps of passive flexion, active extension and active flexion. The aim for the first week is to gain 30deg of active flex for proximal IP joints and 5-10deg for the distal ones. And full finger flexion by the end of the 4th week.

Outcome Measures: Stricklands TAM criteria and a Jamar dynamometer.

Results: No significant differences between the groups for age, sex and life areas. The excellent/ good results for the TAM ranged from 88% in the Strickland group (first place) to 75% in the Kleinert group (last place). The recovery in grip strength, when compared to the uninjured hand, was 92% for the Strickland group and 75% for the Kleinert group. The complete analysis for functional tests at 12 weeks post- op indicates the Strickland protocol, followed by Silfverkiold, Gratton and Kleinert in that order.

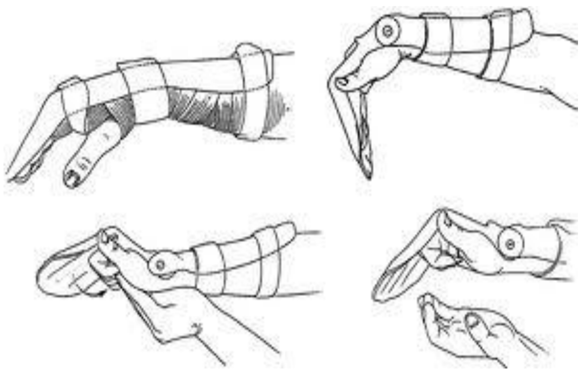


Figure 41Strickland protocol (Strickland 2005)

Appendix 2 Is an example of the Gratton protocol used in St. James' hospital, Dublin.

Although more research is required, it has been determined that the strength of a FTR is related roughly to the number of sutures crossing the repair site. Therefore a four strand suture repair is approximately twice as strong as a two strand suture repair (Klein 2003). These stronger repairs allow more early active motion than previous surgical techniques.

An experimental study by Xie *et al* (2008) demonstrates the changes in tensile strength that a flexor tendon goes through post-operatively. Chickens were used as the experimental model in this study. They have the most similar tendon structure to humans.

Subjects: 46 toes of long feet from 23 white leghorn chickens were used as the experimental model. Divided into 6 operated groups (38 toes) and one control group (8 toes).

Methodology: A Bruner zig-zag incision of 1cm length was made in the plantar skin between the PIP and DIP. This corresponds to zone II in the human. A 1.5cm incision was then made along the centred on the A2 pulley. The same surgeon performed each surgery. Both the FDS and FDP were repaired using a 5-0suture by the modified Kessler method. The sheaths were not repaired. The long toes were then immobilised into a semi-flexed position after surgery. 6/38 toes were harvested on each day of day 1, 2,3,4,5. 8 were completed on day 0.

Outcome Measures: Biomechanical tests of force to resist tendon motion and the work of digital flexion. These were done using a tensile testing machine which the toes could be attached to and tested.

Results: Force to resist tendon mobilisation: The force to resist mob of FDP tendon gradually increased from day 0-5. The forces on day 4 and 5 were significantly higher while the forces between day 0-3 showed no statistically significant difference. The force to resist mobilisation in the control group was the same as that of day 0 in the operated group.

Work of digital flexion:

The work of digital flexion provided the same results as the force to resist tendon mobilisation in relation to increases and the time frame for these.

Limitations: Although chickens they have the most similar tendon structure to humans, there is still differences in the healing processes of the human tendons in the clinical setting.

Another limitation is that this study on looked at resistance to tendon motion in the first 5 days post-op. After this time it was not checked if resistance increased or decreased.

4.6 Complications during Rehabilitation

6.61 Re-Rupture

Unfortunately, there is also a risk for rupture even after repair has taken place. Re-rupture after repair occurs when the suture strength is lower than the gliding force of the tendon needed to overcome resistance to its motion (Xie *et al* 2008). For this reason, it is important for a physiotherapist to be aware of the changes in the resistance to tendon motion post-surgery (Xie *et al* 2008). Rupture can be due to overload of the tendons, oedema, and misuse of the hand or bulky tendons (Griffin *et al* 2012).

Efforts made to prevent this at the rehabilitation stage include immobilisation, positioning and mobilising splints (Thien *et al* 2009). The protocol outlined by Yen *et al* (2008) in the table## is based on a combination of the EAM programmes outlined by Belfast and Sheffield with added modifications by Strickland, namely the 'active-hold' protocol. This programme challenges the strength of the repair in the first 2 weeks. This study found that in a four core strand suture repair, the flexor tendon is strong enough to allow early active finger flexion when protected with a dorsal extension block splint. In this study, one re-rupture occurred in the control group when compared to no re-rupture in the cohort group. This helps to prove the safety and efficacy of the fastened, protected EAM programme. However, this study contains many limitations outlined in the table above and so its results should be interpreted with caution.

Re-rupture occurred in 3% of 129 digits in Saini *et al* (2010). This is in great comparison to 4-17% re-rupture rate occurring in previous series conducted by the same authors that did not use early active mobilisation.

6.62 Adhesions

Peritendinous adhesions are an inevitable element of the healing process post-surgical repair of a flexor tendon (Khanna *et al* 2009). These adhesions produce functional disability. Adhesions most frequently form when there has been an excision of the synovial sheath followed by a period of immobilisation (Khanna *et al* 2009).

Active range of motion has been shown to reduce the formation of adhesions (Griffin *et al* 2012). However, there is a lack of RCT's to define the best mobilisation strategy to reduce adhesion formation (Khanna *et al* 2009). This systematic review by Khanna *et al* (2009) concluded that early post-operative mobilisation is the only thing that has been clinically justified for adhesion prevention.

6.63 Flexion Contracture

Some protocols for FTR use a form of rubber band or elastic traction in order to increase passive flexion of the joints prevent unwanted active movements and reduce tension on the suture line (Klein 2003). However, rubber band traction has been linked with flexion contractures (Klein 2003). Therefore, some protocols have moved away from the idea of traction and have adopted controlled passive motion into their protocol such as Gratton.

4.7 Patient Compliance with Rehabilitation

Even with the most appropriate rehabilitation programme in place, the final recovery after a FTR is very dependent on patient participation with the exercises prescribed (Dobbe *et al* 2002).

Early mobilisation programmes are only appropriate for patients who have the ability to understand both the exercises and the precautions involved with them (Baskies *et al* 2008). If patients are unable, or are unwilling to adhere to strict early mobilisation protocols then immobilisation may have to be considered (Baskies *et al* 2008). This is common in children under 10 years and patients with cognitive difficulties. As discussed earlier, immobilisation results in a poorer outcome post FTR.

4.8 Post Splint Removal

In the majority of protocols, splint wearing is discontinued at the six week point (Baskies *et al* 2008). The exercise regime is continued and progressed at this point but under very controlled and protective instructions. Usually at about eight weeks, gripping activities, more functional tasks and resistance exercises are commenced No heavy resistance tasks are completed until after twelve weeks (Baskies *et al* 2008).

4.9 Rehabilitation Summary

The functional outcome post FTR is dependent on numerous factors including age, injury level and type, type of repair and of course the post repair rehabilitation (Saini *et al* 2010). Most variables except mobilisation have been clearly established previously. The trend towards more active mobilisation appears to be the favourable but more research in this area is required (Griffin *et al* 2012). The most appropriate day to begin digital mobilisation still remains uncertain (Xie *et al* 2008). There is no evidence to support mobilisation without the use of an extension block splint and so this is a common component of most protocols (Yen *et al* 2008).

Overall, the key to success appears to be an early mobilisation post primary repair in a patient that is willing to comply appropriately (Saini *et al* 2010). Regardless of which protocol is chosen, communication between the surgeon, the hand therapist and the patient is paramount for attaining the most successful outcome (Baskies *et al* 2008).

As a hand therapist you will more than likely be instructed on the post-operative protocol to use depending on the surgeons preferences and the preferences of the establishment in which you are working. Most hospitals, clinics, etc will hold copies of these protocols to follow. However, it still remains important that you have an extensive knowledge about all protocols so that you can make a decision with the other members of the MDT on how to adapt certain components to suit individual patient requirements when needed.

Considerations for Future Research

Post-operative FTR rehabilitation is an area that has caused extensive debate in the past number of years. The success of rehabilitation post FTR has improved greatly with the introduction of controlled mobilisation regimes in the early post-operative period. However, the optimum regime has yet to be determined (Thien *et al* 2009). At present, there are numerous methods and protocols for rehabilitation post FTR.

However, these protocols have not been formulated to account for various degrees of injury severity. The difference between a simple cut to the composite loss of tendon tissue must be taken into account and treated appropriately post-surgical repair (Tang 2010). Rehabilitation should also be based on the choice of repair chosen by the surgeon as these can differ depending on the surgeon and the injured tendon (Tang 2010).

A Cochrane review by Thien *et al* (2009) concluded that the best mobilisation strategy cannot be clearly defined as there is limited evidence in the form of RCT's in current literature for rehabilitation post FTR. In the past, research in the area of the basic science of hand therapy has been limited. We will not truly understand the events occurring during therapeutic intervention until we have a greater understanding of the mechanisms of tissue response involved after injury and therapy. This is expected to become a major area for development in future research (Tang 2010).

4.10 Rehabilitation Post Extensor Tendon Injury

The ultimate aim of healing after an extensor injury or an extensor repair is to minimise gapping and adhesions while at the same time promoting healing. The traditional treatment after an extensor tendon repair (ETR) was static mobilisation. However, complications similar to those outlined above post FTR became evident. Early controlled mobilisation has now become the centre of rehabilitation after ETR. Similarly to FTR, the evidence in this area is limited but the most effective strategy appears to be emerging as early post-operative mobilisation. (Griffin *et al* 2012).

Section 5: The MDT in Flexor Tendon Repair

Many members of the MDT have a role in the management of flexor tendon repair.

MDT member	Role
Consultant	Assessment, Surgery, Protocol
Nurse	Post-op care, delivery of pain meds, infection control, change/debulk dressings
Occupational Therapist	Fabricate splint, education, assist return to function
Physiotherapist	Implement EAM regime, education, assist return to function

Table 17: MDT roles

5.1 The Occupational Therapist

5.12 Splints

A splint is a temporary orthopaedic device used for immobilisation, restraint, or support of any part of the body (Coppard 2008)

5.13 Splint Classification System

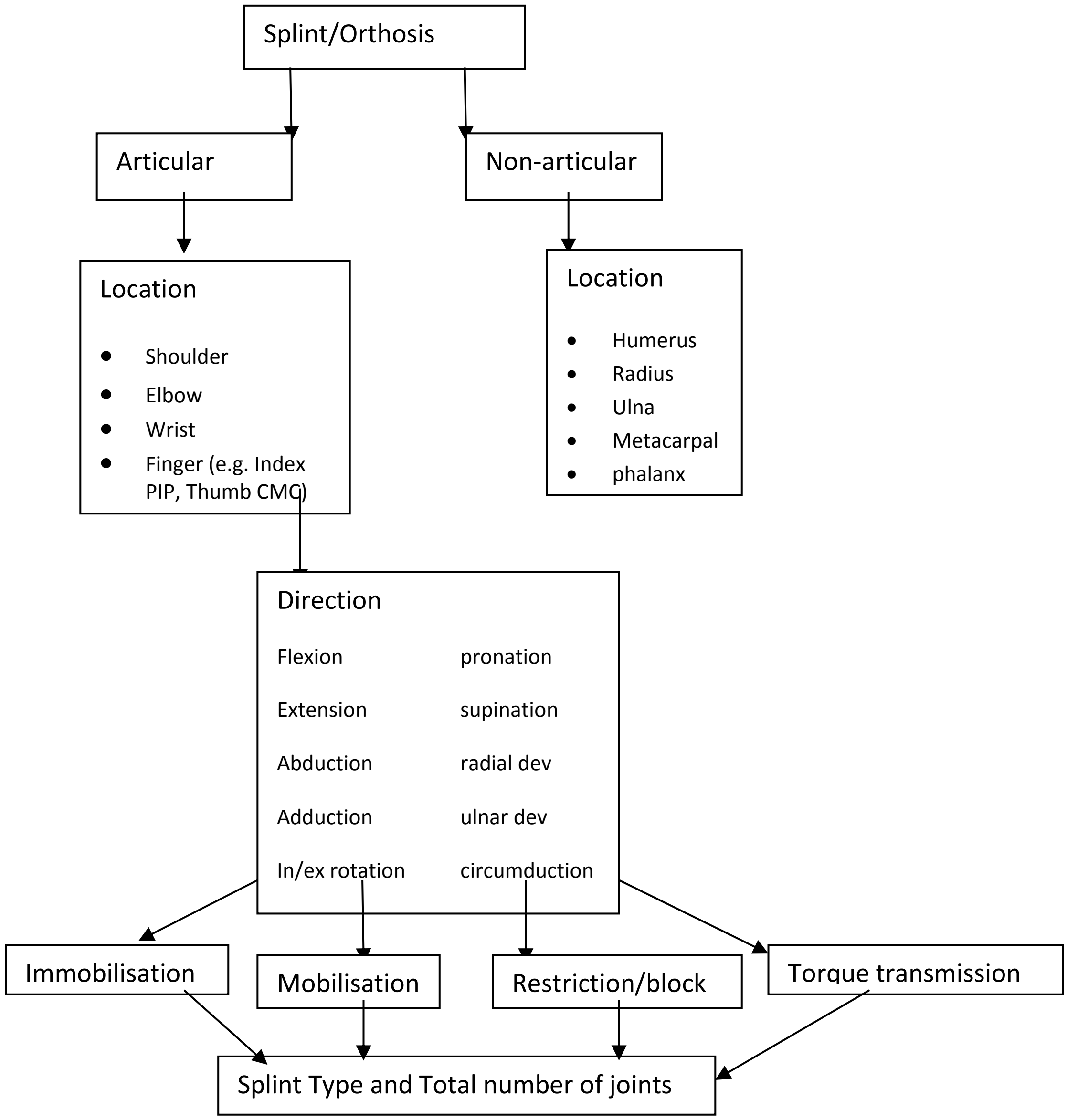


Fig 42 Splint Classification(Coppard and Lohman, 2008)

5.14 Splint type

Specifies the secondary joints included in the splint. Only joint levels are counted, not the number of joints. Joint level type is type 0 if no secondary joints are crossed by the splint.

For example, if a splint is used to flex 4 MCP joints and it crosses the wrist and 4 PIP joints it is called an *index-small finger MCP flexion mobilisation splint, type 2.* It crosses 2 secondary joint levels (wrist and PIP). There are 9 joints in total covered by the splint mentioned above. This can be recorded as type 2 (9). (Coppard and Lohman 2008)

5.15 Splint Designs

In the past splints were categorised as static or dynamic. This terminology is still being used in practice today. Static splints have no moveable parts and place tissues in a stress-free position to enhance healing and minimise friction. Dynamic splints have one or more moveable parts which restrict motion or allow motion in a certain direction. A dorsal block splint used post FTR is an example of a dynamic splint. (Coppard and Lohman 2008)

Flexor Tendon Splint: Forearm based dorsal MCP extension block splint

- Fabricates forearm based dorsal MCP extension block Splint
- Wrist 0° extension. MCPs 70-90° flexion
- Dorsal hood should allow full IPJ extension
- 2 forearm straps
- 1 palmar strap across proximal to distal palmar crease (DPC)
- Double layer tubigrip hood
- Splint to be worn continuously

Figure 43(Pettengill 2005)

Purpose of Splint post flexor tendon repair

Goals of rehabilitation postop flexor tendon repair include;

- Prevent re-rupture of the healing tendon
- Increase tensile strength of the repaired tendon
- Limit scar formation that will limit tendon excursion (Coppard and Lohman 2008)

The dynamic splint assists in attaining these goals by maintaining the hand in a protected position whilst also allowing controlled motion of the joints of the hand (May et al 1992)

Splint must be worn 24 hours per day for 6 weeks. Excellent fit required to ensure patient comfort and compliance.

5.16 Splinting protocol

On referral (Day 1-4 post surgery)	• Fabricates forearm based dorsal MCP extension block splint and applies splint. • Patient education Patient advised regarding: – **Continuous** splint wear x 6 weeks – No functional use of hand while splinted – No passive extension of digits x 6 weeks – No gripping/squeezing/strengthening x 8 weeks – No heavy lifting, driving or contact sports x 12 weeks – Elevation of affected limb in sling – Contact number of therapists given should any problems arise with splint or exercise regimen – Immediate return to casualty if any sudden pop/snap heard or if sudden lack of active range of movement is noted.
Day 10-14	• Routine review. Splint reviewed for fit and comfort, altered as required. • Precautions and education reinforced.
Week 6	Routine review. • Splint removed. Advise nightwear for two weeks • Commence light functional activities • Outline no driving, no lifting, no contact sports • Assess for need for flexion strapping phase I/II. Advise 4 times daily wear for 20 minutes

Week 8	• Serial static extension splint if flexion deformities present. • Commence scar management e.g. silicone gel / cream or elastomere
Week 10	• Commence dynamic spring extension splinting for PIP flexion contractures • Advise 4 times daily x 10 minutes
Week 12	Return to • full function • Lifting • Driving • Contact sport

Table 18: OT protocol for FTR rehabilitation (UCHG, 2012)

5.17 Compliance with splinting regime

- Two thirds of patients (67%) report to have removed their splint within the first four weeks after flexor/extensor tendon repair
- Of this group 76% removed their splint between one and six times over the four week period for less than one hour
- 24% removed their splint daily and for more than one hour

(Sandford et al 2008)

Factors shown to increase compliance	Factors shown to decrease compliance
The greater the pts perceived interference of the injury to valued functional tasks	Poor perceived efficacy of Rx: lack of feedback and monitoring of outcome measures
The greater the degree of disability	
The greater the perceived efficacy of Rx	Failure of therapist to communicate the expectation of positive results (no matter how small!)
Feedback: reports of improvement in outcome measures	
Recognition of pts efforts	Discomfort
Pt-therapist relationship: knowledgeable, trustworthy, confident therapist.	patient-therapist relationship: poor communication, ignoring concerns of the patient
Collaborative goal setting	Interference with function (especially washing and dressing)
Patient education on reasons for wearing splint, consequences of not wearing splint, difficulties that the pt may encounter whilst wearing the splint and strategies to overcome them e.g. splint hygiene, washing	Poor education of patient: unclear instructions and failure to explain the rationale behind the instructions

Table 19: Factors relating to compliance with splint wearing (Sandford et al 2008; Groth and Wulf 1995; Sluijs et al 1993)

Section 6: Psychosocial Effects

A challenging rehabilitation regimes following flexor tendon surgery require patients to complete an hourly exercise regime and wear a thermoplastic splint constantly for a six week period. Therefore a physiotherapist must be aware of the possible psychosocial elements attached to this frustrating disability.

There is limited research published which directly examines the psychosocial effect of a flexor tendon repair patients. The following is a summary of two papers published in this area.

Branford *et al* (2007)

Title: Patients' concerns with the journey through flexor tendon rehabilitation - a prospective patient-centred satisfaction survey

Subjects: 32 subjects (18 Male, 14 Female)

Methodology: The questionnaire was completed by patients during the 3rd, 7th and 12th week of rehabilitation.

Outcome measures: A prospective questionnaire survey

Results: At 7 weeks 66% of male and 100% of female subjects reported having difficulty with everyday activities. 61% of males and 88% of females responded that life was not in their control. 63% of females and 43% of males reported feeling concerned about their hand at 12 weeks. Overall approximately 40% of respondents wanted more information about their repair and prognosis at the 7th and 12th week of rehabilitation.

Conclusion: The study suggests that there should be a strong therapist-led emphasis on providing verbal and written information throughout flexor tendon rehabilitation to increase knowledge and reduce associated anxiety.

Limitation: The study was carried out over the first 12 weeks post repair. No follow up after this was carried out which did not take into consideration the long term impact of a flexor tendon repair. The questionnaire used had set answers which may not have given a true representation of the patient's views.

Fitzpatrick and Finlay (2008)

Title: "Frustrating disability" The lived experience of coping with the rehabilitation phase following flexor tendon surgery

Subjects: 5 flexor tendon repair surgery patients, 2 male 3 female 23-54 year age range

Methodology: Patient led interviews immediate post-surgical repair

Outcome measures: Patient led interviews analysed using a phenomenological approach

Results: Themes which emerged from the analysis included 1) struggling to adapt 2) retreating-battling 3) denying-accepting. 4) Effect on aspects of daily living 5) Emotional and social struggle due to personal relationship disruption.

Limitation: Small subject base may not represent whole patient group.

Despite the limited evidence, the above two papers combined with anecdotal evidence suggest there are key areas which must be discuss in depth with flexor tendon patients in the days immediately post repair. It is important to note that due to the nature of the rehabilitation process for a flexor tendon injury the physiotherapist is the healthcare professional who will have the most contact time with the patient. Therefore the role of the physiotherapist will often extend beyond the boundaries of the rehabilitation regime. Key areas to discuss are;

6.1 Occupation

Depending on an individual's occupation a flexor tendon patient may find themselves unable to work for up to a three month period of time. It is important to discuss this with the patient as it is often a major area of concern. Early return to work may result in re rupture or a poor outcome. Patients may be entitled to partial capacity benefit or short term disability allowance during this time. It is important to make the patient aware of this. Information on this can be found in the appendices or from www.citizensinformation.ie.

6.2 Mental health status

A person's mental health can have a direct effect on exercise adherence (Brosse *et al* 2002). Due to the importance of a strict rehabilitation regime for a flexor tendon repair adherence is crucial. Therefore the patient's mental health status and concerns about the rehabilitation process should be discussed on an ongoing basis throughout the rehabilitation process.

6.3 External Supports

Adequate external support in the form of family, friends etc. are vital to aid the person with activities of daily living. This is pivotal in the achievement of best possible outcome and in limiting the possibility of re rupture. Inclusion of external support is crucial to ensure all involved have a thorough understanding of the rehabilitation.

Part 3:

Workbook

1.1 Burns Quiz

Please match the burn to the Description of the burn type

Superficial (1st degree) burn

Superficial partial burn (2a)

4th degree burn

Deep partial burn (2b)

Deep (3rd degree) burn

1.2 Healing Quiz

STAGE	TIMESCALE	PROCESS	SIGNS AND SYMPTOMS

1.2 Burns Case Study

Burns Case Study : Angela

- 23yr old female
- Severe 2nd and 3rd degree burns and severe smoke inhalation injury following rescue from burning house:
    1. Full thickness burns over chest
    2. superficial-partial thickness burn to face/neck
- BIBA to ED, prior to arrival at hospital the patient was intubated

On arrival at ED:

- On Ax soot present in mouth and nasal hair singed
- Chest and anterior axillary escharotomy performed
- Red partial thickness wounds are clean, no infection noted
- 2nd degree burns over 10% of body, and 3rd degree burns over 30% of body. Covering face, neck and thoracic regions
- Vitals unstable:
    1. BP 55/35, HR 210, RR 40,
    2. deteriorating from circulatory failure,
    3. 2 IVs inserted and fluids administered,
- Vitals stabilised and transported to ICU

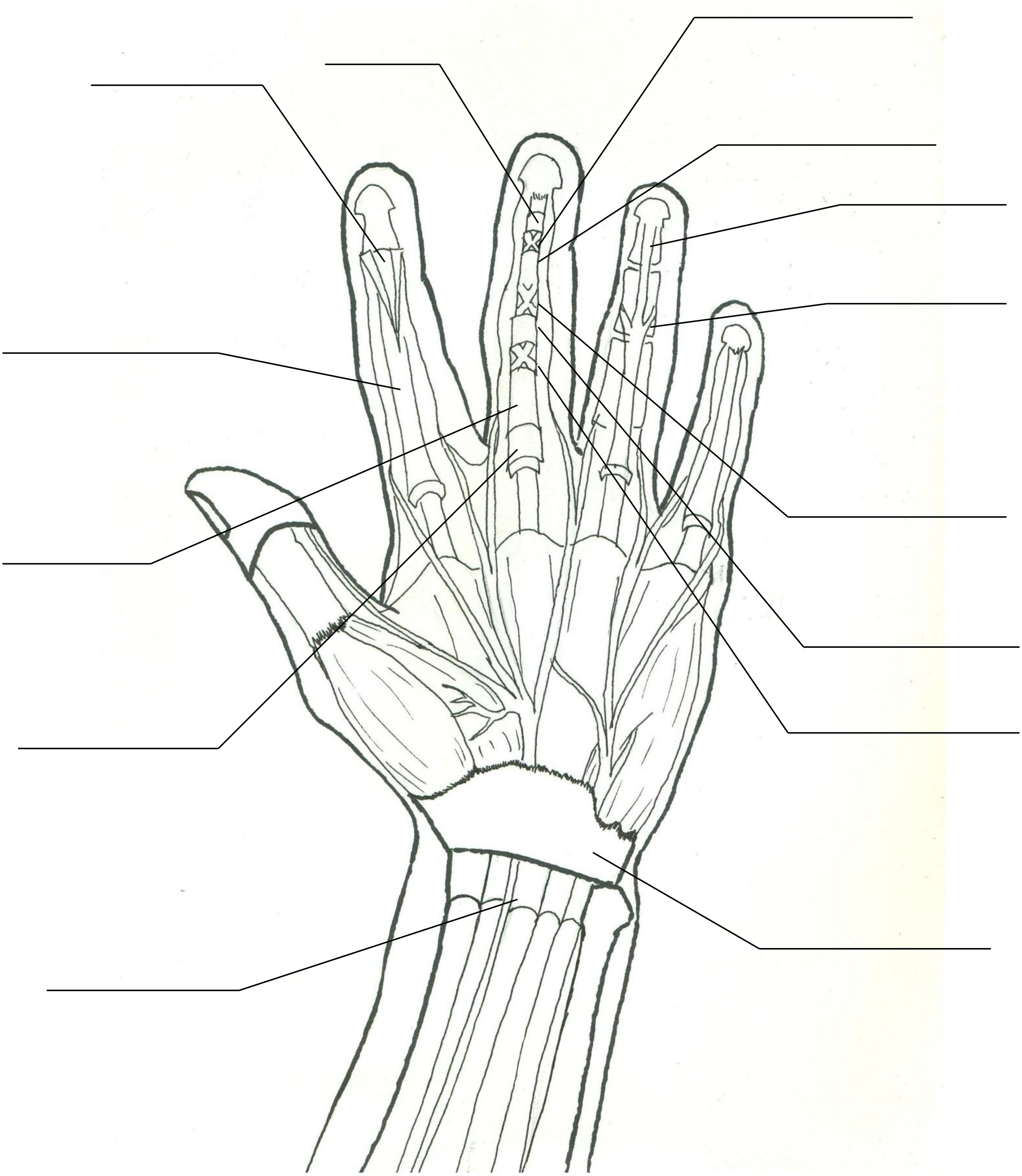
ICU:

- Lungs are clear with productive cough of small amount of carbon tinged sputum.
- Surprisingly complaining of only minor pain over the chest. Pain 5/10 NRS
- Following debridement of burns and application of broad spectrum topical anti biotic.
- An autograft epidermal graft was placed over her face, taken from her thigh. A translocational flap was applied over her chest

Management:

- Position in bed changed every 2 hours to prevent bed sores
- Lost 9lbs over the next 3 weeks, despite 5000cal/day ng feeding
- After 9 weeks sheets of cultured epidermal cells were grafted to her regenerating dermal layer on her face
- By week 15, epidermal graft was complete. Back on solid foods. d/c from hospital with rehab plan for Physio and OT at home.

1.4 Hand Anatomy Quiz



Appendix

Patient Information Sheet (Adapted from St James' Hospital, Dublin)

Rehabilitation Post Flexor Tendon Repair

The tendons that bend your finger(s) and

have been repaired. They must be protected in a

Dorsal Blocking Splint. ➔➔➔➔

This splint must be worn at all times for 4 or 6 weeks (this is dependent on the decision made in clinic)

DO NOT REMOVE YOUR SPLINT.

DO THE FOLLOWING EXERCISES EVERY 3 HOURS

Exercise No. 1

- Give your shoulder and elbow a full stretch above your head.
- Bend your elbow to 90^0 keeping it tucked in to your waist; turn the palm of your hand up to face the ceiling then down to face floor.
- Reach your thumb over to touch the base of your little finger

REPEAT TEN TIMES

Exercise No 2. Gently bend all your fingers towards the palm of your hand, and then allow them to stretch back to the splint.

REPEAT THREE TIMES

Exercise No 3.

Using your other hand, slide one finger behind the middle knuckle and place your thumb on the nail . Gently push each finger towards the palm of your hand.

REPEAT THREE TIMES

Exercise No. 4

Using your other hand, slide one finger behind the middle knuckle and straighten the top of your finger. This should stretch the front of your finger.

DO NOT PUSH YOUR FINGER BACK

REPEAT THREE TIMES

DO NOT USE YOUR HAND IN ANY OTHER WAY, NO LIFTING, GRIPPING, PULLING, OR DRIVING. ONLY DO THE EXERCISES DESCRIBED.

Key References

Burns Key References

Austin, K.G., Hansbrough, J.F., Dorc, C., Noordenbos, R.N., Buono, M.J. (2003) 'Thermoregulation in burn patients during exercise', *Journal of Burn Care Rehabilitation*, 24, 9-14

Cooper, C. (2007). *Fundamentals of Hand Therapy: Clinical Reasoning and Treatment Guidelines for Common Diagnoses of the Upper Extremity*. Mosby Elsevier: St. Louis, Missouri.

Disseldorp, L.M., Nieuwenhuis, M.K., Van Baar, M.E., Mouton, L.J. (2011) 'Physical fitness in people after burn injury: A systematic review', *Arch Phys Med Rehabil* 92 1501-1509

Esselman P.C. (2007) 'Burn Rehabilitation: An Overview', *Arch Phys Med Rehabil* 88 (12) 3-6

Esselman, P.C., Thombs, B.D., Magyar-Russell, G. and Fauerbach, J.A. (2006) 'Burn Rehabilitation: State of the Science', *American Journal of Physical Medicine and Rehabilitation*, 85, 383-413.

Glassey, N. (2004) *Physiotherapy for burns and plastic reconstruction of the hand,* United Kingdom: John Wiley & Sons Ltd.

Grisbrook, T.L., Wallman, K.E., Elliot, C.M., Wood, F.M., Edgar, D.W., Reid, S.L. (2012a) 'The effect of exercise training on pulmonary function and aerobic capacity in adults with burn', *Burns,* 38, 607-613

Kamolz, L.P., Kitzinger, H.B., Karle, B. and Frey, M. (2009) 'The treatment of hand burns', *Burns,* 35 (3), 327-337.

Okhovatian, F., Zoubine, N. (2007) 'A comparison between two burn rehabilitation protocols', *Burns*, 33, 429-434.

Pape, S.A., Judkins, K., Settle, J.D. (2000) *Burns: the first five days: international edition,* 2nd ed., Hull: Smith and Nephew Healthcare Ltd.

Richardson, P. ad Mustard, L. (2009) "The management of pain in the burns unit", *Burns,* 35 (7), 921-936.

Willis C.E., Grisbrook, T.L., Elliot, C.M., Wood, F.M., Wallman, K.E., Reid, S.L. (2011) 'Pulmonary function, exercise capacity and physical activity participation in adults following burn', *Burns*, 37, 1326-1333

Standards of Physiotherapy and Occupational Therapy Practice in the Management of Burn Injured Adults and Children (2005) London: The British Burn Association.

Occupational Therapy and Physiotherapy: Principles and Guidelines for Burns Patient Management (2002) Sydney: Australia and New Zealand Burns Association.

Reconstructive Surgery Key References

Bal S, Oz B, Gurgan A, Memis A, Demirdover C, Sahin B, Oztan Y (2011) 'Anatomic and functional improvements achieved by rehabilitation in zone II and zone V flexor tendon injuries' Am J Phys Med Rehabil, 90, 17-24

Baskies, M.A., Tuckman, D.V. and Paksima, N. (2008) 'Management of flexor tendon injuries following surgical repair', *Bulletin of the NYU hospital for joint diseases*, 66(1), available: SPORTDiscus (accessed 26th Jan 2013).

Boscheinen-Morrin, J., Connolly, W.B. (2001) 'The Hand: Fundamentals of Therapy' 3rd Ed, Butterworth-Heinemann: Oxford

Cappagh National Orthopaedic Hospital (2012) *Physiotherapy Protocols* [online] available: http://www.cappagh.ie/physiotherapy-protocols

Duke Orthopaedics: Wheeless Textbook of Orthopaedics (2012) 'Flexor Tendon Repair' [online] available: http://www.wheelessonline.com/ortho/flexor_tendon_repair [accessed 15 January]

Elliot, D. (2002) 'Primary Flexor Tendon Repair- Operative repair, pulley management and rehabilitation' The Journal of Hand Surgery; 27 (6), pgs. 507-513. Academic Search Complete, EBSCOhost, viewed 16 January 2013.

Griffin, M, Hindocha, S, Jordan, D, Saleh, M, & Khan, W (2012) 'An Overview of the Management of Flexor Tendon Injuries', Open Orthopaedics Journal, 6, S1, pp. 28-35, Academic Search Complete, EBSCOhost, viewed 17 January 2013.

Kitis, A., Buker, N., and Gokalan Kara, I. (2009) 'Comparison of two methods of controlled mobilisation of repaired flexor tendons in zone 2', *Scandinavian Journal of Plastic*

Surgery, 43(3), available: http://informahealthcare.com/doi/abs/10.1080/02844310902864122 (accessed 25th Jan. 2013).

Klein, L. (2003) 'Early active motion flexor tendon protocol using one splint', *Journal of Hand Therapy,* 16(3), available: http://www.sciencedirect.com/science/article/pii/S0894113003000358 (accessed 24th Jan. 2013).

Sandford, F., Barlow, L., Lewis, J.L. (2008) 'A Study to Examine Patient Adherence to Wearing 24-Hour Forearm Thermoplastic Splints after Tendon Repairs', *Journal of Hand Therapy,* 21: 44-53.

Sharma, P., Maffulli, N. (2005) 'Basic biology of tendon healing', Surgeon, 3 (5) 309-316

Thien, T.B. Becker, J.H. and Theis, J.C. (2009) 'Rehabilitation for flexor tendon injuries in the hand (review)' *Cochrane Database of Systematic Reviews,* Issue 1.

Yen, C.H., Chan, W.L., Wong, J.W.C and Mak, K.H. (2008) 'Clinical Results of early active mobilisation after flexor tendon repair', *Hand Surgery,* 13(1), p.p. 45-50.