A CLINICAL STUDY ON RESURFACING HAND DEFECTS

Dissertation submitted to

THE TAMILNADU DR. MGR MEDICAL UNIVERSITY

In partial fulfillment of the regulations for the award of the degree of

Mch [PLASTIC SURGERY]

BRANCH III

RAJIVGANDHI GOVERNMENT GENERAL HOSPITAL
MADRAS MEDICAL COLLEGE
THE TAMILNADU DR.MGR MEDICAL UNIVERSITY,
CHENNAI

AUGUST 2012

DECLARATION

I solemnly declare that this dissertation **[A C**linical study on Resurfacing hand defects]** was prepared by me in the department of Plastic, Reconstructive and Faciomaxillary Surgery, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai under the guidance and supervision of Professor & HOD Department of Plastic, Reconstructive and Faciomaxillary Surgery, Madras Medical College, and Rajiv Gandhi Government General Hospital, Chennai between 2009 and 2012.

This dissertation is submitted to the Tamilnadu Dr.MGR Medical University, Chennai in partial fulfillment of the university requirements for the award of degree of Mch Plastic surgery.

Place :

Date :

CERTIFICATE

This is to certify the dissertation titled **[A CLINICAL STUDY ON RESURFACING HAND DEFECTS]** was done under our supervision and is the bonafide work of **Dr.R.VIVEK**. It is submitted in partial fulfillment of the requirement for the Mch Plastic Surgery Examination.

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ACKNOWLEDGEMENT

I am thankful to the **Dean, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai** for permitting me to carry out this study.

I am very grateful to **Professor K.V.ALALASUNDARAM, Retired Professor, Madras Medical College and Rajiv Gandhi Government General Hospital** for his expert guidance without which this study would not have been possible.

I am profoundly grateful to **Professor R.ANANDASUBRAMANIUM, Prof. & Head of the Department of PLASTIC AND RECONSTRUCTIVE SURGERY** for his invaluable guidance in the preparation and completion of this Study. I am also thankful to professors **R GOPINATH, UDESH GANAPATHY, K.GOPALAKRISHNAN and PALANIVEL [Retd.]** for their advice and support throughout the study.

I thank Dr.T.M.Balakrishnan, Dr Sreedevi, Dr Saravanan, Dr Ramadevi, Dr Boopathi, Dr Selvakumar, Dr Arunkumar Assistant Professors of our department for their advice and encouragement. I am especially happy to thank my co residents for their comments, correction and help in the execution of effort. I am extremely thankful to all my patients who readily consented and cooperated in the study.

CONTENTS

AIM OF STUDY

PRIMARY OBJECTIVE

To analyze and discuss the various established reconstructive options for defects of the hand.

SECONDARY OBJECTIVE

To arrive at a logical conclusion for selecting the reconstructive procedures considering the functional and aesthetic outcome.

INTRODUCTION

The functional outcome of a hand injury cannot be fully assessed at the time of injury alone. The measure of functional outcome must incorporate the evaluation and severity of the initial injury and the subsequent reconstructive surgeries. The complexity of the hand deserves no less. Restoration of prehensile function is the top priority in reconstruction following hand injuries, and assessment of outcome should address this goal. Flaps and specialised tissue grafts can restore architecture and balance in the hand. The surgical management of complex and extensive[1] soft tissue defects is a challenging problem; reconstruction requires regional, distant pedicle or free flaps. It is the soft tissue envelope of hands that transfers touch, sensibility, temperature feeling, and grip. Stable but flexible integument is also required for the extremely important individualized intensive physiotherapy after hand injuries. The primary objective of the surgeon must be to preserve as much function as possible of the injured parts by maintaining the length of osseous structures, sparing any viable skin and subcutaneous tissue, and preserving the nerves, tendons, and vascular structures for subsequent reconstruction. Fixation of fractures and repair of other structures injured are important before coverage to allow early

mobilization and restoration of function. The use of spare parts from otherwise unsalvageable limb represents the ultimate form of reconstruction that probes the creative mind and challenges the reconstructive knowledge of the surgeon. Spare parts represent those components that may be overlooked in a pile of unusable and mutilated tissues. These undamaged and potentially usable elements include skin, bone, tendons, vessel, nail bed, or portions of composite functional units such as hand or fingers.

The concept of the axial pedicle flaps[2] and its application created the possibility of reliable immediate coverage for extensive wounds in which appropriate coverage needed. Treatment of hand injuries is based on the assessment of the injury and the selection of the proper reconstructive method.

Different methods of reconstruction are available for the treatment of hand defects; pedicled groin flaps, distal pedicle reversed radial forearm fasciocutaneous flaps, posterior interosseous flaps and free flaps. An optimal outcome demands that the attending surgeon pay close attention to the problem in all its preoperative, intraoperative and postoperative phases, at both donor and recipient sites.

SYSTEMATIC APPROACH

Patient specific factors

- Age
- General health
- Mobility
- Comorbidity
- Profession
- Socio economic status

Defect Genesis

- Crush
- Penetration
- Degloving
- Thermal
- Amputating

Localization

Size and Depth

Exposed structures

Structures to be reconstructed

Contamination

Surrounding Tissue

SURGICAL ANATOMY OF HAND

PALM OF HAND

The skin of the palm of the hand is characterized by flexure creases and papillary ridges, which occupy the whole of flexure surface. The ridges serve to improve the grip and they increase the surface area. Sweat glands abound, but there are no sebaceous glands. It is bound to the deep fascia by numerous fibrous bands. The little Palmaris brevis muscle is attached to the dermis. It lies across the base of hypothenar eminence and is the only muscle supplied by superficial branch of ulnar nerve. It may improve the grip by steadying the skin on the ulnar side of palm.

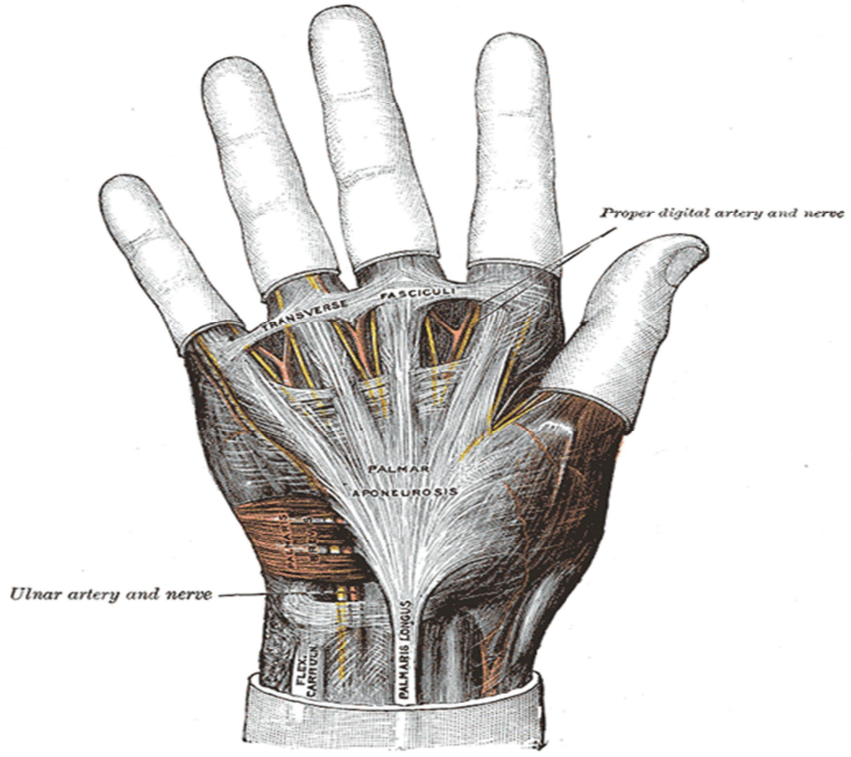
The subcutaneous fat pad is composed firm adherent globules separated by vertical septa and fibres that run between the palmar fascia and the dermis. These loculi of fat can change their shape but not their volume, within its fascial framework. This soft pad allows the hand to conform to the contours of objects being grasped, allowing better interpretation of sensation and better grip.

DEEP FASCIA

The deep fascia of the palm is thickened to form flexor retinaculum and palmar aponeurosis.

PALMAR APONEUROSIS

The palmar aponeurosis is triangular and occupies the central area of palm. It is continuous proximally with the flexor retinaculam. The medial and lateral borders of the palmar aponeurosis are continuous with the thinner deep fascia covering the hypothenar and thenar muscles. It widens distally in the hand and divides into four slips one for each finger. The function of palmar aponeurosis is to give firm attachment to the overlying skin and so improve the grip and to protect the underlying tendons. A thickening of transversely directed fibres at the level of the heads of metacarpal bones constitutes the superficial transverse metacarpal [natatory] ligament]



FLEXOR RETINACULAM

It is a strong fibrous band, measuring 2-3cm in transversely and longitudinally, which lies across the front of carpus at the proimal part of hand. It is attached to hook of hamate and pisiform medially and to the tubercle of the scaphoid and the ridge of trapezium laterally. The median nerve and all the long flexor tendons of the fingers and thumb pass through this tunnel. The median nerve passes deep to the flexor retinaculam between flexor digitorum superficialis tendon to middle finger and flexor carpi radialis. The ulnar nerve lies on the front of the retinaculam lateral to pisiform bone, with the ulnar artery lateral to nerve. Nerve passes through the guyons canal in which the nerve may occasionally be compressed. The tendon of Palmaris longus is partly adherent to the anterior surface of the retinaculam, which is also crossed superficially by the palmar cutaneous branches of ulnar and median nerves lying medial and lateral, respectively to the tendon.

DORSUM OF HAND

The skin of the dorsum is thin and can be picked up from the underlying deep fascia and tendons and moved freely over them. There is usually little subcutaneous fat here. It is attached to the hand's

skeleton only by loose areolar tissue, where lymphatics and veins course. This fact explains why edema of the hand is manifested predominantly at the dorsum. In addition, this loose attachment of skin makes the dorsum of the hand more vulnerable to skin avulsion injuries and also permits the creation of local flaps. The deep fascia and the subjacent extensor tendons roof in a sub fascial space that extends across the width of the hand. The Dorsal carpal arch is an arterial anastomosis between the radial ulnar and anterior interosseous arteries. It lies on the back of carpus and sends dorsal metacarpal arteries distally in the intermetacarpal spaces, deep to the long tendons.

MEDIAN NERVE

Proximal to the wrist, the palmar cutaneous branch provides sensation at the thenar eminence. Median nerve enters the palm beneath the flexor retinaculam. Distal to the retinaculam it enlarges and flattens and gives a muscular recurrent branch which curls proximally around the distal border of flexor retinaculam to supply the thenar muscles. (abductor pollicis brevis, opponens pollicis, and superficial head of flexor pollicis brevis). It also innervates the index and long finger lumbrical muscles. Sensory digital branches provide sensation to the thumb, index, long, and radial side of the ring finger.

ULNAR NERVE

At the hand, the superficial branch, which can be palpated on the hook of hamate supplies Palmaris brevis and divides into two digital nerves, which provide sensation at the small finger and ulnar aspect of the ring finger. The deep motor branch passes through the Guyon canal in company with the ulnar artery. It innervates the hypothenar muscles (abductor digiti minimi, opponens digiti minimi, flexor digiti minimi, and palmaris brevis), all interossei, the 2 ulnar lumbricals, the adductor pollicis, and the deep head of the flexor pollicis brevis. Proximal to the wrist, the palmar cutaneous branch provides sensation at the hypothenar eminence. The dorsal branch, which branches from the main trunk at the distal forearm, provides sensation to the ulnar portion of the dorsum of the hand and small finger, and part of the ring finger.

RADIAL NERVE

At the proximal forearm, the radial nerve divides into the superficial and deep branches. The deep posterior interosseous branch innervates all the muscles in the extensor compartment: supinator, extensor carpi radialis brevis, extensor digitorum communis, extensor digiti minimi, extensor carpi ulnaris, extensor indicis proprius, extensor

pollicis longus, extensor pollicis brevis, and abductor pollicis longus. Near its termination it supplies the wrist joint.

The superficial branch passes behind brachioradialis provides sensation at the radial aspect of the dorsum of the hand, the dorsum of the thumb, and the dorsum of the index finger, long finger, and radial half of the ring finger proximal to the distal interphalangeal joints.

EXTRINSIC EXTENSORS

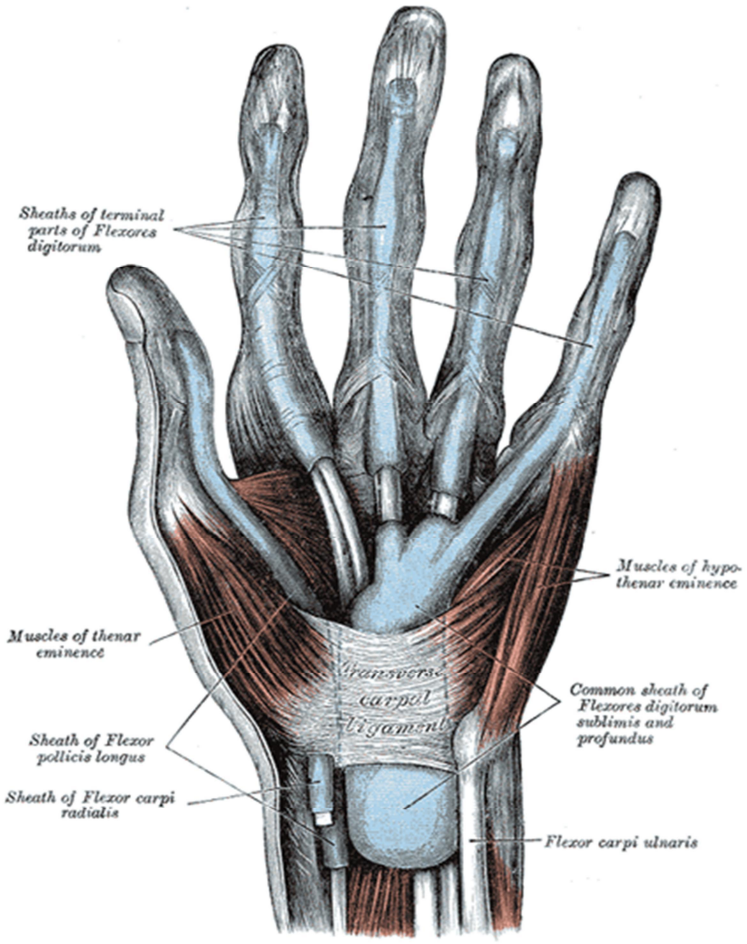
The extensor muscles are all extrinsic, except for the interosseous - lumbrical complex, which is involved in interphalangeal joint extension. All of the extrinsic extensor muscles are innervated by the radial nerve

The extensor carpi radialis brevis (ECRB) is the main extensor of the wrist, along with the extensor carpi radialis longus (ECRL) and extensor carpi ulnaris (ECU), which also deviate the wrist radially and ulnarly, respectively. The ECRB inserts at the base of the third metacarpal, while the ECRL and ECU insert at the base of the second and fifth metacarpal, respectively.

The extensor digitorum communis, extensor indicis proprius, and extensor digiti minimi extend the digits. They insert to the base of the middle phalanges as central slips and to the base of the distal phalanges as lateral bands. The abductor pollicis longus, extensor pollicis brevis, and extensor pollicis longus extend the thumb. They insert at the base of the thumb metacarpal, proximal phalanx, and distal phalanx, respectively.

The extensor retinaculum is a band like thickening in the deep fascia of the forearm about 2. 5cm wide, which lies obliquely across the extensor surface of wrist. Its proximal attachment is to the anterolateral border of the radius above the styloid process. It is not attached to the ulna its distal attachment is to the pisiform and triquetral bones. It prevents bowstringing of tendons at the wrist level and separates the tendons into 6 compartments. The extensor digitorum communis is a series of tendons to each digit with a common muscle belly and with intertendinous bridges between them. All the tendons are invested with a common synovial sheath. The index and small finger each have independent extension function through the extensor indicis proprius and extensor digiti minimi. Lastly the groove near the base of the ulnar

styloid transmits the tendon of extensor carpi ulnaris in its synovial sheath.



EXTRINSIC FLEXORS

The extrinsic flexors consist of 3 wrist flexors and a larger group of thumb and digit flexors. They are innervated by the median nerve, except for the flexor carpi ulnaris (FCU) and the flexor digitorum profundus to the small and ring finger, which are innervated by the ulnar nerve.

The flexor carpi radialis is the main flexor of the wrist, along with the flexor carpi ulnaris and the palmaris longus, which is absent in 15% of the population. They insert at the base of the third metacarpal, the base of the fifth metacarpal, and the palmar fascia, respectively. The FCU is primarily an ulnar deviator. The 8 digital flexors are divided in superficial and deep groups. Along with the flexor pollicis longus, which inserts at the thumb distal phalanx, they pass through the carpal tunnel to provide flexion at the interphalangeal joints.

At the palm, the superficial tendons overlie the profundus tendons as they pass in pairs into fibrous flexor sheaths of fingers. It then splits at the level of the proximal phalanx and reunites dorsal to the profundus tendon to insert in the middle phalanx. The flexor digitorum profundus perforates the superficialis tendon to insert at the distal phalanx. The relationship of flexor tendons to the wrist joint, metacarpophalangeal joint and interphalangeal joint is maintained by a retinacular or pulley system that prevents the bowstringing effect.

INTRINSICS

The intrinsic muscles are situated totally within the hand. They are divided into 4 groups: the thenar, hypothenar, lumbrical, and interossei muscles.

The thenar group consists of the abductor pollicis brevis, flexor pollicis brevis, opponens pollicis, and adductor pollicis muscles. All are innervated by the median nerve, except for the adductor pollicis and deep head of the flexor pollicis brevis, which are innervated by the ulnar nerve. The most radial of these is abductor pollicis brevis. Opponens pollicis lies deep to the other two muscles. They originate from the flexor retinaculum and carpal bones and insert at the thumb's proximal phalanx.

The hypothenar group consists of the palmaris brevis, abductor digiti minimi, flexor digiti minimi, and opponens digiti minimi. They are all innervated by the ulnar nerve. This group of muscles originates at the flexor retinaculum and carpal bones and inserts at the base of the proximal phalanx of the small finger.

The lumbrical muscles contribute to the flexion of the metacarpophalangeal joints and to the extension of the interphalangeal joints. They originate from the flexor digitorum profundus tendons at the palm and insert on the radial aspect of the extensor tendons at the digits. The index and long finger lumbricals are innervated by the median nerve, and the small and ring finger lumbricals are innervated by the ulnar nerve.

The interossei group consists of 3 volar and 4 dorsal muscles, which are all innervated by the ulnar nerve. They originate at the metacarpals and form the lateral bands with the lumbricals. The dorsal interossei abduct the fingers, whereas the volar interossei adduct the fingers to the hand axis.

The wrist joint is a complex, biaxial synovial joint that allows wide range of motion in flexion, extension, circumduction, radial deviation, and ulnar deviation. The distal radioulnar joint allows pronation and supination of the hand as the radius rotates around the ulna. The radiocarpal joint includes the proximal carpal bones and the distal radius. The fibrocartilaginous disc, which holds the lower ends of radius and ulna together, separates the radiocarpal joint from distal radioulnar joint. The proximal row of carpals articulates with the radius and ulna to provide extension, flexion, ulnar deviation, and radial deviation. Dorsally, it is supported by the dorsal intercarpal ligament between the scaphoid and triquetrum and by the dorsal radiocarpal ligament. A capsule surrounds the joint and is thickened to form the palmar dorsal and collateral ligaments.

At the intercarpal joints, motion between carpal bones is very restricted. These joints are supported by strong intrinsic ligaments. The

2 most important ones are the scapholunate ligament and the lunotriquetral ligament. All 4 distal carpal bones articulate with the metacarpals at the carpometacarpal (CMC) joints. The second and third CMC joints form a fixed unit, while the first CMC forms the most mobile joint. In the resting position, the wrist is in slight adduction and extension.

The metacarpophalangeal joints are synovial joints. They allow of flexion extension abduction and adduction. The palmar ligaments are strong pads of fibrocartilage, which limit extension at the joint. Lateral motion is limited by the collateral ligaments, which are actually lateral oblique in position, rather than true lateral. This arrangement and the shape of the metacarpal head allow the ligaments to be tight when the joint is flexed and loose when extended (i.e. cam effect). The volar plate is part of the joint capsule that attaches only to the proximal phalanx, allowing hyperextension. The volar plate is the site of insertion for the intermetacarpal ligaments. These ligaments restrict the separation of the metacarpal heads.

Interphalangeal joints are pure hinge joints no abduction being possible. Extension is limited by the volar plate, which attaches to the phalanges at each side of the joint. Radial and ulnar motion is restricted

by collateral ligaments, which remain tight through their whole range of motion and have oblique alignment to that in the metacarpophalangeal joints.

BLOOD SUPPLY

The radial artery runs distally in the forearm between the brachioradialis and flexor carpi radialis muscles. At the wrist, it crosses dorsally deep to the tendons of the "anatomic snuffbox" to enter the palm and form the deep palmar arch. A superficial branch arises at the level of the wrist and contributes to the superficial palmar arch.

Posterior interosseous artery gains the extensor compartment by passing between the bone of forearm above the interosseous membrane and below the oblique cord. The arterial supply of the extensor compartment is supplemented by anterior interosseous artery, which pierces the interosseous membrane above the upper border of pronator quadratus.

The ulnar artery travels to the hand through the Guyons Canal, where it divides into the deep palmar branch and the superficial palmar branch. The superficial branch forms the superficial palmar arch, and the deep branch contributes to the deep palmar arch. Superficial palmar arch

is often not a complete arch. The arch lies across the centre of palm, level with the distal border of outstretched thumb web.

The superficial palmar arch lies directly deep to the palmar fascia. It gives rise to the volar common digital arteries and multiple branches to intrinsic muscles and skin. Distal in the palm, the common digital arteries bifurcate into the proper digital arteries. In the palm, the arteries lie volar to the corresponding nerves, a relation that is reversed in the digits. At the digits, the neurovascular bundle always lies volar to the ligament of Cleland. Deep palmar arch lies at the base of the metacarpals deep to the flexor tendons. It is the major blood supply to the thumb and radial half of the index finger by the first metacarpal artery. After giving its branch to the index finger, it is called the princeps pollicis.

The dorsal arteries originate proximally from the posterior interosseous artery and a dorsal perforating branch of the anterior interosseous artery. Dorsal metacarpal arteries arise from a dorsal carpal arch formed by the previously mentioned arteries and are the source of multiple local hand flaps (dorsal metacarpal artery flaps).

Common digital arteries arise from the superficial palmar arch to form proper digital arteries at the webs. The palmar aspect of the digits receives arterial flow through these proper digital arteries. The dorsum of each digit, distal to the proximal interphalangeal joint, is vascularized by dorsal branches of the proper digital arteries. The deep palmar arch is an arterial arcade formed by the terminal branch of the radial artery anastomosing with deep branch of ulnar artery.

Veins generally follow the deep arterial system as venae comitantes. A superficial venous system also exists at the dorsum of the hand and contributes to the cephalic and basilic vein in the upper extremity.

The pulley system is critical to flexion of the finger. The retinacular system for each of the fingers contains 5 annular pulleys and 4 cruciate pulleys. The sheaths are dense and stiff over the phalanges and the centres of the joints forming annular pulleys. In between these annular pulleys the sheath are thin and lax, here the fibres have a cruciate arrangement forming cruciform pulleys. The thumb has 2 annular pulleys and 1 oblique pulley. In the finger, the second and fourth annular pulleys (A2, A4) are critical pulleys. The oblique pulley is the critical pulley in the thumb. A2 and A4 pulleys arise exclusively from

the bone and are broad and rigidly fixed to the outer edge of proximal phalanx and middle phalanx. They are called biomechanical pulleys. A1, A3, A5 pulleys arise from bone and volar joint plate. They adjust with movement holding the flexor tendons close to the joint.

REVIEW OF LITERATURE

In the early days of the world war, patients were randomly assigned to plastic, orthopedic, neurosurgical or general surgical units. Over time, however, it became increasingly evident that a multidisciplinary approach was necessary in the care of the injured hand. Therefore, a ward designated specifically for hand surgery was created and led by a plastic surgeon, J. William Littler. Furthermore, because of the fact that plastic surgeons have expertise in wound coverage and trauma reconstruction, regional hand centers were then set up in hospitals known for plastic surgery.

Dr. Alan Kanavel was a general surgeon in Chicago who gained a great experience in infections of the hand. He published a landmark text on this subject in 1932. Dr. Sterling Bunnell was another general surgeon who was known for the emphasizing the importance of gentle handling of tissues, the use of the tourniquet, nerve grafts, pollicization of the index finger, among numerous other things. There are many orthopedic surgeons who have furthered the development of hand surgery. Dr. Harold Kleinert advanced our current knowledge of tendon repair and healing as well as contributing to knowledge in the revascularization of the upper extremity. Drs. Dieter Buck-Gramcko,

Adrian Flatt and Joseph Upton are three orthopedic surgeons who have imparted invaluable experience in the care of children with congenital hand deformities.

Dr. Sumner Koch was a plastic surgeon who made advances in skin coverage, the treatment of tendon and nerve injuries as well as in the treatment of Dupuytren's disease. He was made president of the American Society for Surgery of the Hand in 1950. Sir Harold Gillies, another plastic surgeon, made great strides in our understanding of skin flap surgery. More recently, plastic surgeons have advanced the field of microsurgery. Neurovascular anastomoses are performed for thumb reconstruction as well as for digital replantation. Improvements in our understanding of nerve injury and regeneration, along with refinement in microsurgical techniques has allowed us to perform procedures on peripheral nerves that relieve nerve compression or to repair injured nerves following traumatic events. Better understanding of muscle physiology, nerve repair and biomechanics has enable hand surgeons to restore function to the injured hand.

Foucher and associates described a free radial forearm flaps with tendons of Palmaris longus, flexor carpi radialis, and brachioradialis.

An island flap based on the dorsalispedis artery was first introduced by Obrien and Shanmugam. Acland clarified the microanatamic details of the cutaneous branches of dorsalispedis artery.

In1947, Cave and Rowe described using skin from deformed and useless fingers to cover defects in the hand. A similar principle was outlined by bunnell in which a fillet flap of a finger was used to cover hand defects. The use of palmar skin of amputated fingers to cover appropriately sized hand defects was reiterated by Slocum. As stated by Peacock, A finger contains all the basic tissues which are found elsewhere in hand and when the finger ceases to be an integral part of hand, it should be viewed as a valuable source of spare tissue.

The use of perionychium as spare parts for reconstruction of fingertip injuries has been illustrated by Van Beek.

Gainer described in 1985 an osteocutaneous fillet flap for reconstruction of thumb in a gunshot wound of hand.

Alpert and Buncke described using free vascularized island flap from a nonviable amputated digit to cover a palmar hand wound.

STERLING BUNNELL CONCEPT [1944]

The hand is so intricate in structure that if dissected in turns by three different specialists it is likely to be wrecked beyond repair. The bones, joints, muscles, tendons, nerves, skin are all parts of a composite mechanism in the function of hand and they can best be repaired by the surgeon who assumes responsibility for the whole. Hand surgery is an area specialty not a tissue specialty.

Algorithms based on the reconstructive ladder help in decision making about soft tissue coverage. Based on the case profile the quickest, easiest, safest and best suited methods have to be used for the best possible outcome. This implies that even a sophisticated free flap procedure is no longer considered as an ultimate option, but is choosen rather early if it provides the best possible result.

RECONSTRUCTIVE ALGORITHMS

All reconstructive procedures must be preceded by a thorough surgical debridement. Necrotic and questionably viable material is carefully excised. The resulting defect after debridement is often much larger than previously estimated.

In devastating hand injuries, the surgeon is rarely confronted with superficial skin losses which can be closed by split and full thickness skin grafting.

SKIN GRAFTING

The first option of open wounds or after secondary release of contractures of upper extremity is skin grafting[3]. In areas without exposed vital structures skin grafting is the simplest technique. In small wounds, thinned full thickness grafts harvested from groin or flexion crease of upper extremity can provide durable skin that is less likely to contract. Wound coverage with skin grafts might not be ultimately successful because of the possible problems of breakdown and scarring. If the skin graft periodically ulcerates, it is deemed unstable and might need to be replaced with more durable cover. In addition if the healed skin graft causes joint contracture or limitation in tendon excursion, then this initial attempt at wound coverage might need to be excised and replaced with full thickness flap tissue. The high contracture potential, limited scar flexibility, and disappointing sensibility limit their successful use in hands, except in donor areas of locoregional flaps.

EXAMPLE :- A CASE OF POST BURN CONTRACTURE RELEASE & SKIN GRAFTING.

LOCAL FLAPS

Complex full thickness of the integument are more frequently encountered in complex trauma to hand. Local flaps often play only a minor role in mutilating hand injuries, but can still be importance in special reconstructions by providing sensibility to fingertips. There is abundance of local flaps in the hand, but the hand surgeon should be familiar with some reliable examples. Fingertip injuries can often be treated with various transposition flaps to provide a stable fingertip with acceptable two-point discrimination. The ideal procedure for fingertip injuries should maintain length and should cover the defect with non-tender, well-padded skin that has normal or near normal sensation.

ATOSAY TRIANGULAR VOLAR V-Y ADVANCEMENT FLAP

The dorsal oblique amputation is the best indication for this method. In transverse amputations remaining part of the distal phalanx must be shortened a few millimeters, in order to facilitate the procedure. This flap is contraindicated for palmar oblique amputations with extensive soft tissue loss. The subcutaneous tissue must be left undisturbed, because it contains the neurovascular supply to the flap.

Since a longer flap is easier to advance, the apex of the triangle should be placed at the distal flexion crease.

KUTLER LATERAL TRIANGULAR SKIN FLAPS TO THE FINGERTIP

This procedure should be considered for patients with a true transverse guillotine amputation. Because this procedure uses bilateral, midlateral fingertip tissue, it is ideal for secondary stump revisions with a broad unsightly tip. The neurovascular supply courses through the subcutaneous tissue and must be protected during dissection and advancement of flap.

Smaller defects on the lateral aspect and the dorsum of the fingers are preferably closed with pedicled flaps, especially when the extensor mechanism is exposed. Cross finger flaps, flaps based on the dorsal metacarpal arteries bring their own blood supply and provide stable coverage, rapid healing, and good pliability. However they are limited in their availability. The larger the primary defect, the less the soft tissue available for flap coverage. Additionally elevation of local flap inflicts additional injury to the traumatized upper extremity. The resulting compound wound can further impair hand function.

CROSS FINGER FLAP

Cronin is credited with popularizing cross finger flap[15]. Indication or this flap is

- Early coverage of exposed flexor tendons and digital nerves
- Resurfacing of scarred volar skin causing a flexion contracture
- Coverage of exposed Bone, interphalangeal joints, and extensor tendons on the dorsal surface

In severe hand injuries with involvement of several regions of hand, availability of local flaps is frequently limited because of potential damage to donor area. In these cases, regional or distant flaps provide more safety.

OTHER FLAPS AVAILABLE FOR FINGER INJURIES

- Rectangular lateral neurovascular island skin flap
- Oblique triangular skin flap
- Volar v-y cup flap
- Flag skin flap
- On top plasty skin flap
- Thenar flap
- Louvre skin flap

REGIONAL FLAPS

RADIAL FOREARM FLAP

The best known axial pattern flap in upper extremity is the **Radial forearm flap**[9, 10, 11]**,** based on the radial artery. A reverse flow radial forearm flap can be based distally on the radial artery and venae comitantes, there by permitting the transfer of volar forearm skin to the hand without the need for micro vascular anastomoses. It can only be used if the patency of both major vessels is preserved and an Allens test has been performed before the operation. The venous outflow in a reversed flap[21] is provided by a crossover or bridging between two venae comitantes. The disadvantage of reversed flap is venous congestion. The forearm is a safe and reliable donor area for a variety of tissues and these flaps are relatively easy to raise from injured arm. The pedicle is long, large and of constant anatomy, but includes one of the main arteries of hand, which can sometimes impair perfusion to hand. The forearm can provide upto 8x10cm of thin hairless skin, which can be used to resurface the dorsum of hand or palm. The disadvantages of these skin flaps are skin grafted scars on the forearm, postoperative hypoesthesia on the dorsum of hand and sacrifice of radial artery. The

flap is raised from proximal to distal and is based on six to ten perforators found at the distal portion of forearm.

POSTERIOR INTEROSSEOUS ARTERY FLAP

The reverse pedicled **Posterior interosseous artery flap**[17,18], initially described by Zancolli has specific merits, including the preservation of the major vessels in the hand and a relatively good aesthetic results at the donor site with primary closure of 4 to 5cm. A line is drawn between the lateral epicondyle and the distal radioulnar joint representing the course of posterior[19] interrosseous artery. The skin incision begins at the level of the distal anastomosis between the two interosseous arteries and continuous along the radial side of the flap. The fascia is incised longitudinally over the extensor carpi ulnaris and extensor digiti minimi muscles. Blunt dissection identifies the artery between these muscles. Artery is divided at its proximal origin near the distal edge of supinator muscle. Ulnar side of the flap is incised, elevated and then dissected down to the distal anastomosis with anterior interosseous[22,23,24] artery. The main drawback of this flap is that it in involves a complex and time consuming dissection of the vascular pedicle. There are anatomic variations and there are limits to the size allowed by primary closure.

DORSAL ULNAR ARTERY FLAP

Becker described a fasciocutaneous flap in 1988 based on this branch of the ulnar artery arising 2 to 4 cm proximal to the pisiform bone. It passes deep to musculotendinous junction of flexor carpi ulnaris with the dorsal branch of ulnar nerve. It divides into ascending and descending branches that supply the ulnar border of forearm wrist and hand. The ascending branch forms the vascular basis for a distally pedicled island flap upto 5to 10cm in width and 10 to 20cm in length, with potential to reach defects over the dorsum of hand, ulnar half of palm and the dorsal and volar wrist.

DISTANT FLAPS

Distant flaps are harvested from thorax, groin, trunk, and flanks. These flaps are useful for large defects including the dorsum of hand and forearm. One of the most important distant flaps is the groin flap. MC Gregor and Jackson were the first to describe the **Groin flap**[4] in 1972. A groin flap is a medially based flap that can be of either axial or random vascularity, thereby allowing its donor site to close primarily. The flap is usually based on the superficial circumflex iliac artery that arise from the femoral artery approximately 2cm below the inguinal

ligament. The superficial circumflex artery traverses laterally within the subcutaneous fat and the pierces the deep fascia to lie superficially lateral to Sartorius muscle. The vessel runs parallel and inferior to the inguinal ligament toward anterior superior iliac spine, where the blood supply to the skin lateral to this point is random in nature. It is easier to raise this flap from distal to proximal in the subcutaneous plane. If the lateral border of Sartorius is encountered, fascia of the Sartorius and medial tissue must be taken with the flap. It is used mostly as an ipsilateral pedicled flap[6], which is divided after 3 weeks, but can also be as a free flap. Generally this flap will be approximately 10x15cm in size. The definitive advantage is its donor site where primary closure is often possible upto a width of 10 to 12cm and scar is easily hidden. The groin flap provides good coverage for the defects of the hand and distal forearm. However the hand must remain dependent during the attachment process, which can be uncomfortable and increase edema formation and the lack of exercise can result in joint stiffness. Furthermore, this type of flap can be bulky and might contain much subcutaneous fat; however, this can be debulked if desired. Finally the patient treated with a groin flap[5] needs to be very compliant throughout the whole pedicled phase, especially when physiotherapy is performed in this stage.

EXAMPLE OF INFERIORLY BASED ABDOMINAL FLAP FOR COVERING DORSUM HAND DEFECTS.

FREE FLAPS

Microvascular[7, 8] free flaps demonstrate the highest versatility of all soft tissue coverage procedures and are among the first choices in treating mutilated hands. The main advantages are that they can be harvested in almost any size required, are raised from a distant donor site, bring their own blood supply and angiogenic and lymphogenic potential, and not only cover defects but actively improve venous and lymphatic drainage of the traumatized area. They permit the elevation of the hand and early mobilization. However, a free flap must be thin enough to provide good coverage and must include a gliding surface for tendon function. Although they are frequently inferior to local flaps regarding texture and colour match, this is considered less important in mutilating injuries. Free flap should have adequate dimensions, and allow harvesting of additional tissue components, which make complete single stage reconstructive procedures possible. [Chimeric flap]

The lateral arm fascial flap[12] pedicled by posterior radial collateral artery provides thin fascia and acceptable results. The advantages of this flap are the reliable and long pedicle, primary donor site closure and possible innervations. The antebrachial fascial flap requires the sacrifice of the radial artery. The scapular fascia flap is

often thick, especially in obese people. The serratus anterior fascial flap is as thin as temperoparietal fascial flap, and its donor site morbidity is low resulting in thin scar easily hidden with clothes.

SENSORY SKIN FLAPS

This includes dorsalis pedis flap[13,14,16] along with superficial peroneal nerve, deltoid flap with lateral brachial cutaneous nerve, lateral arm flap with antebrachial cutaneous nerve of arm and forearm and radial forearm flap with superficial branch of radial nerve or medial or lateral antebrachial cutaneous nerve.

OSTEOCUTANEOUS FLAPS

These flaps[20] include segments of ilium with a groin flap, metatarsus with a dorsalis pedis flap, humerus with a lateral arm flap, rib bone with serratus anterior muscle flap, radius with radial forearm flap, ulna with ulnar forearm flap and lateral border of scapula with a scapular skin flap.

MATERIALS AND METHODS

The study was conducted in the Department of plastic, Reconstructive, Maxillofacial Surgery, Madras Medical College and Rajiv Gandhi Govt. General Hospital, Chennai during the period September 2009 to February 2012.

Thirty patients were examined and analysed based on the established reconstructive options and operated in emergency or elective settings.

PREOPERATIVE ASSESSMENT

Pre operatively assessment included a thorough history and physical examination. Time and mechanism of injury, age, hand dominance, occupational status and general health of the patient are the factors considered before surgery. The hand and the digits were assessed with regard to vascular status, degree of contamination, and severity of soft tissue loss. Skeletal assessment was done with plain X-rays of the wrist and hand. The degree of commination, bone loss and intra articular damage was studied. Basic blood investigations were done. Informed written consents were obtained from all patients. Prophylactic antibiotics was given to all patients.

INTRAOPERATIVE MANAGEMENT

The main priority in the acute management of hand injuries was given to restore the vascularity to the hand and digits. Skeletal stabilization, musculotendinous repair, nerve repair was done. Finally soft tissue coverage was done to restore the overall function to the hand. Thorough wound irrigation was done and debridement done under tourniquet control. Metacarpal and carpal bones were fixed. Flexor and extensor tendon repair completed if injured. Tourniquet is deflated and complete excision of the devitalized skin, fascia, and muscle back to bleeding tissue was done.

FACTORS CONSIDERED IN CHOOSING CORRECT OPTION

Defect will be analyzed on what are the structures lost for example bone, tendon and what are structures remaining for reconstruction of the defect. Reconstructive procedure selection also looks for colour match, texture match and pliability.

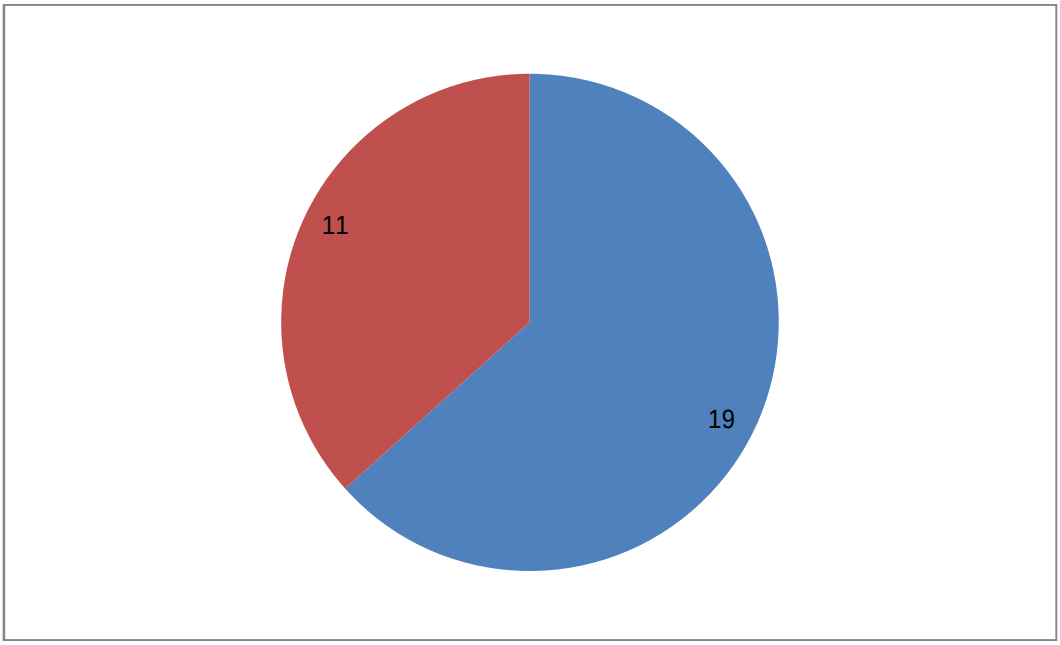
Also the method which consumes least time and less number of stages but providing the maximal function is selected.

Post operatively patient after discharge from the ward was followed up every week for first two months, then every two weeks for next three months. Physiotherapy was started as soon as the flap settled to prevent stiffness and for early rehabilitation.

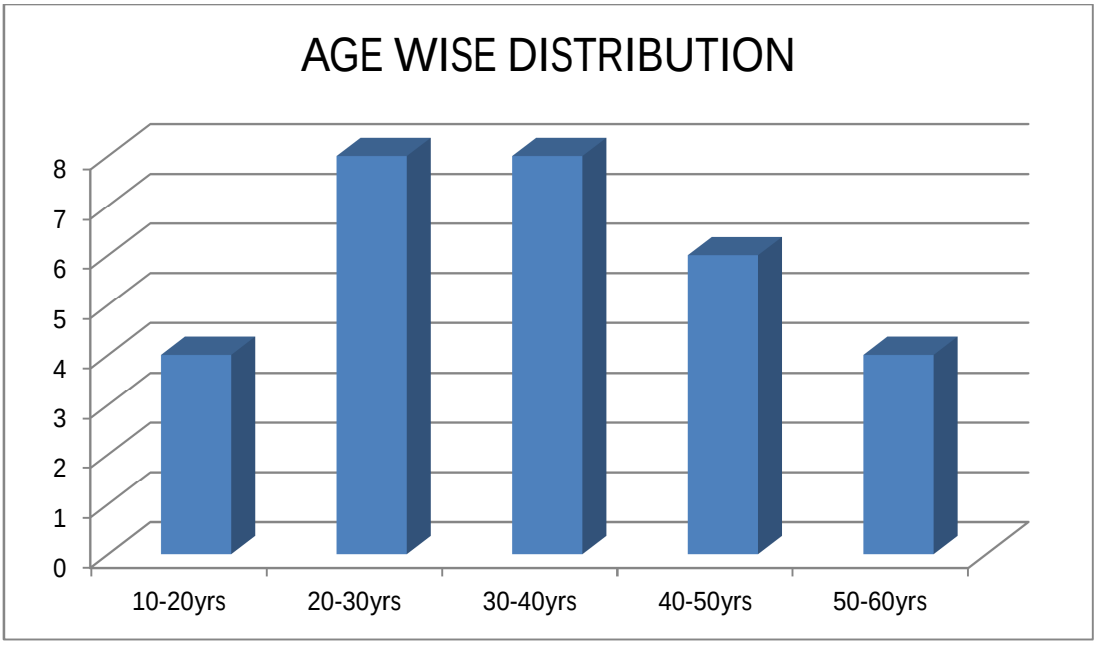
OBSERVATIONS

AGE AND SEX DISTRIBUTION

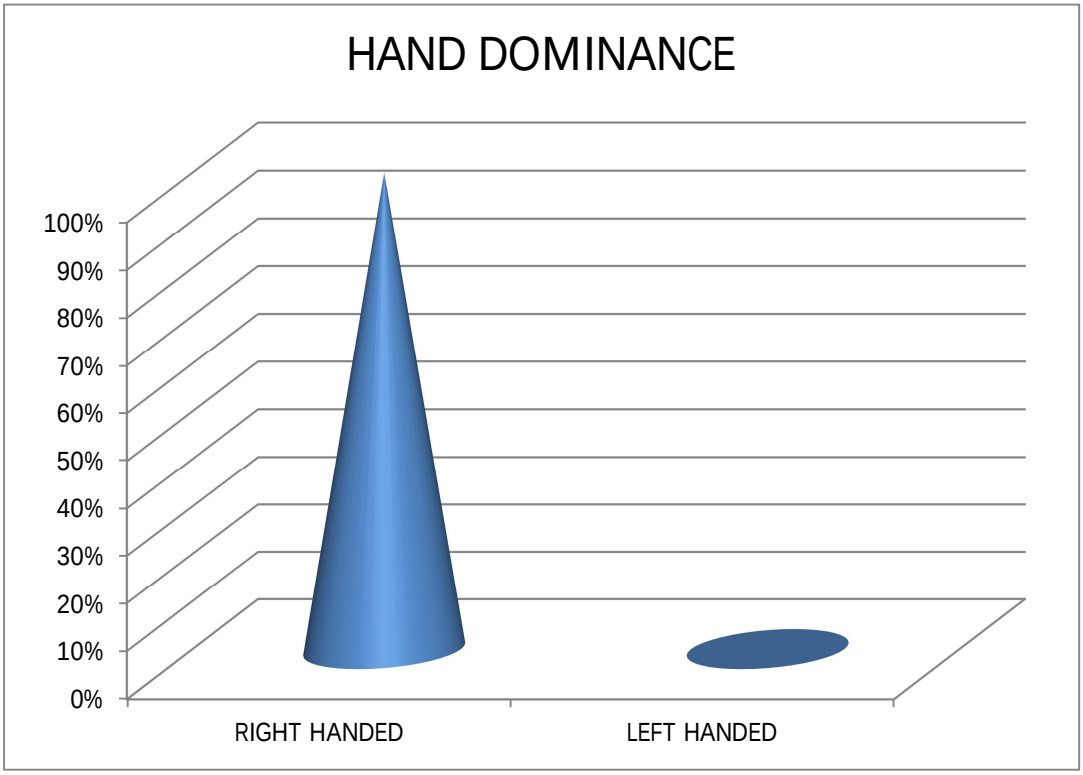
Eleven patients were females and the rest were males.



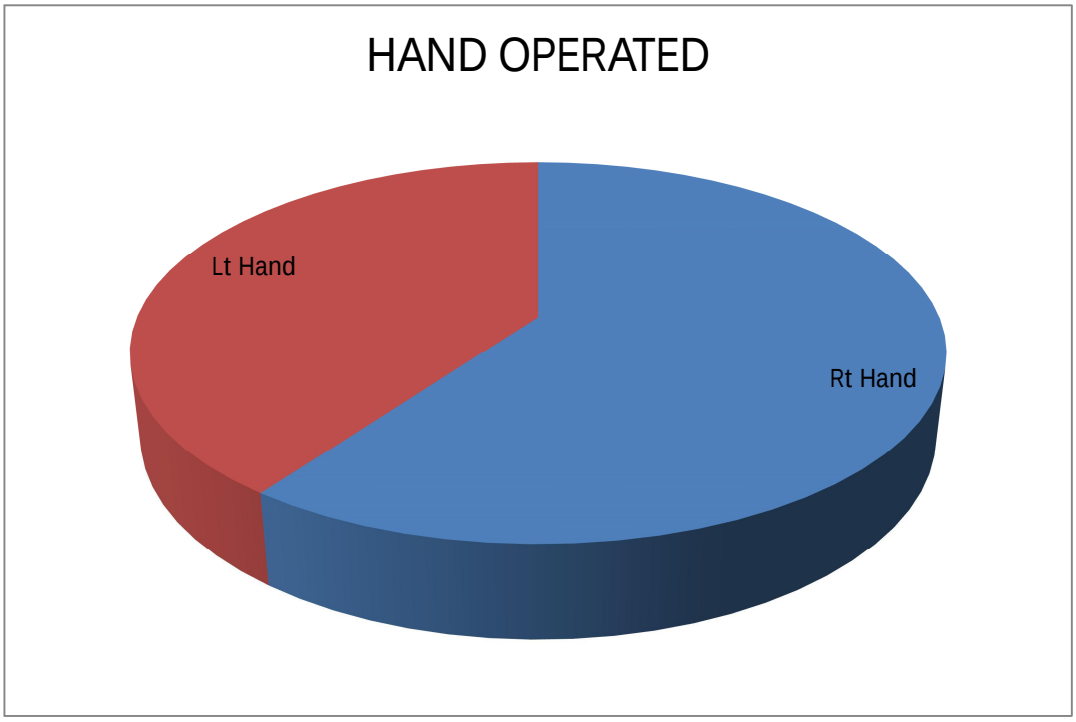
The age of the patients ranged from nine to fifty-five years.



All patients were right handed.



Twelve patients were operated on nondominant hand (i. e. Left hand).



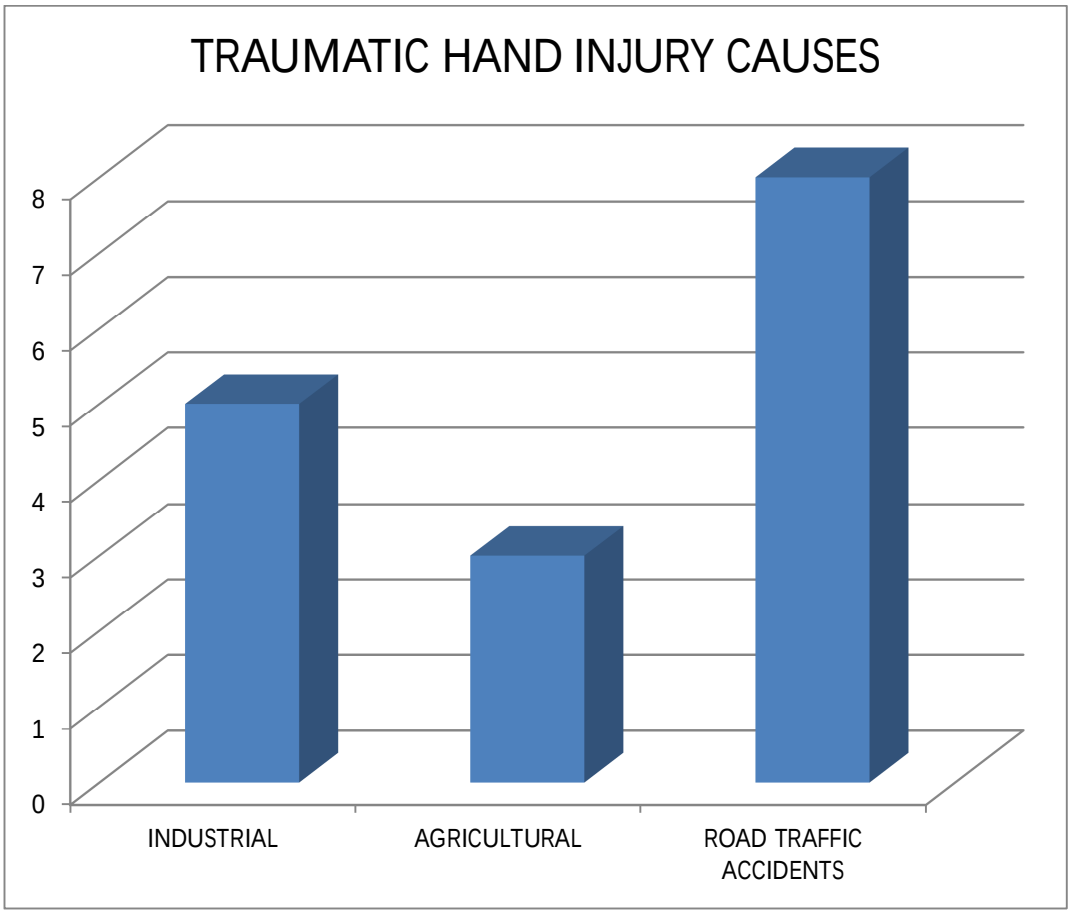
DISTRIBUTION-ETIOLOGY

Post traumatic defects - 16

Industrial trauma - 5

Agricultural machinery - 3

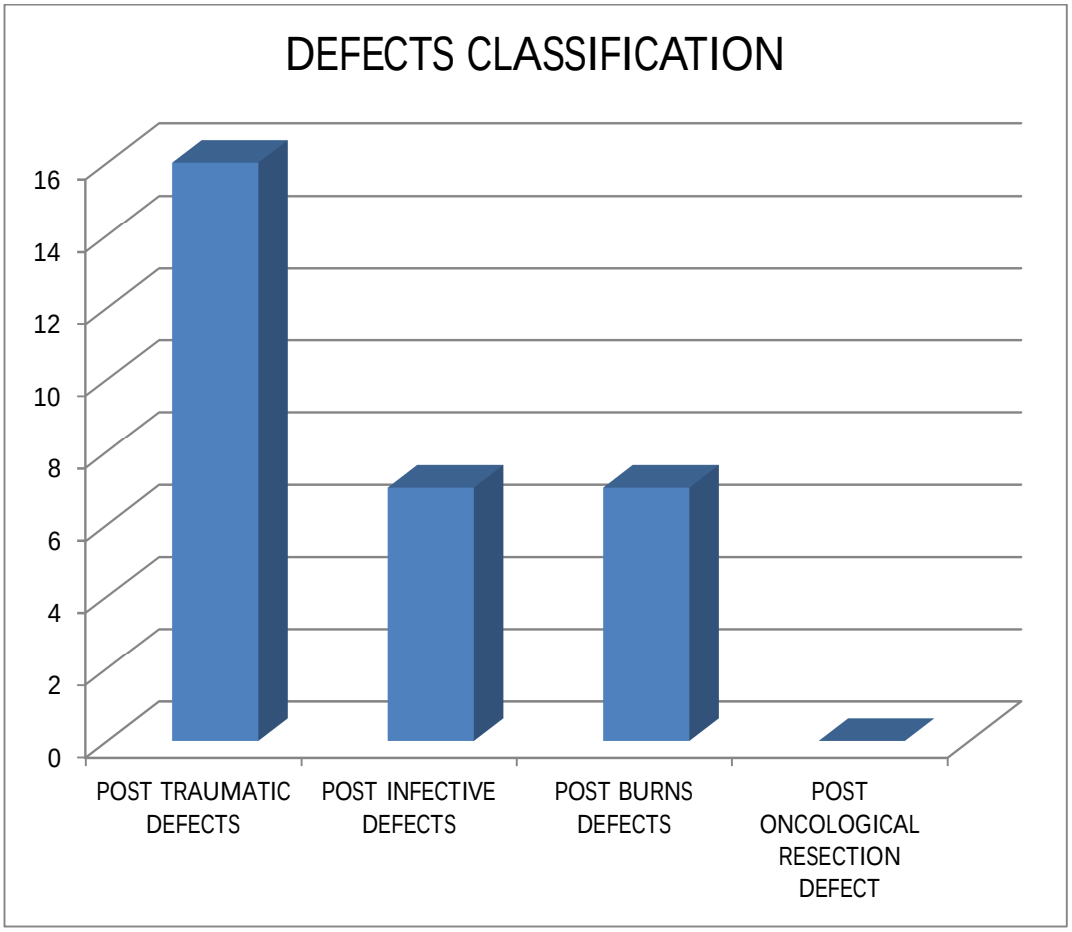
Motor vehicle accidents - 8



Post Infective defects - 7

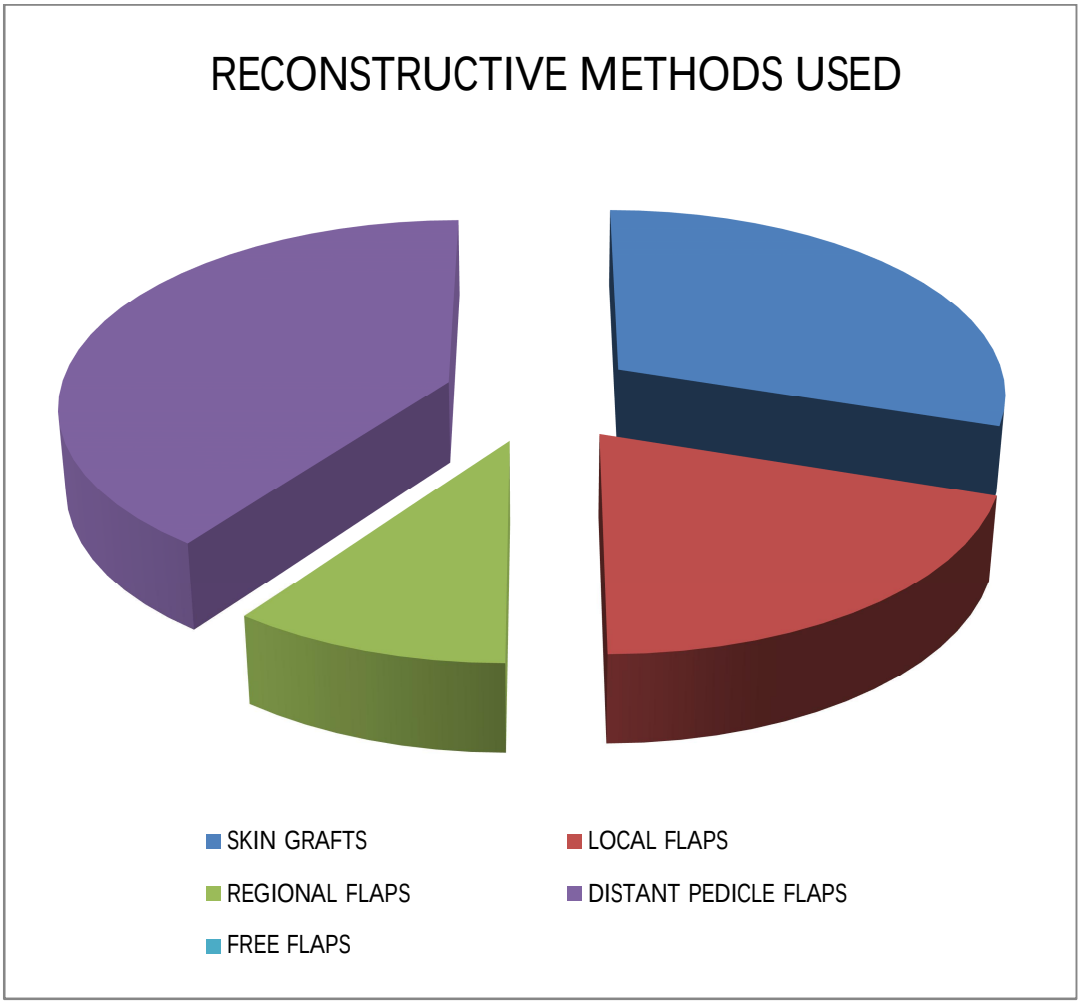
Post burns secondary defects - 7

Post oncological resection defects - 0


DEFECTS CLASSIFICATION
16
14
12
10
8
6
4
2
0
POST TRAUMATIC DEFECTS
POST INFECTIVE DEFECTS
POST BURNS DEFECTS
POST ONCOLOGICAL RESECTION DEFECT

RECONSTRUCTIVE OPTIONS USED

1	-	Skin Grafts	-	9
2	-	Local Flaps	-	6
3	-	Regional Flaps	-	3
4	-	Distant Pedicled Flaps	-	12
5	-	Free Flaps	-	0



REPRESENTATIVE CASE REPORTS

CASE REPORT-1

50/F presented with post traumatic soft tissue defect over the Right dorsum of hand following road traffic accident sustained one week back. On examination wound of size 8x8cm over the first web space and extending to the dorsum of hand and exposing the underlying extensor tendons. Xray showed no underlying fracture. She was planned for cover of defect using Groin flap from the ipsilateral side. Pedicled groin flap cover was done. Flap division done after 3 weeks. Flap settled well. Donor site closed primarily.

CASE REPORT-2

33/F presented with post infective soft tissue defect over the volar aspect of proximal and middle phalanx of left middle finger exposing flexor tendons 10 days duration. She was a diabetic patient and right handed individual. Initially it started with pain and swelling with abcess formation, incision and drainage done elsewhere. she was planned for cross finger flap from the ring finger dorsal surface to cover the exposed flexor tendons. Cross finger flap was done. Flap division done after 2 weeks. Donor area covered with split skin graft. Flap settled well and graft take was good.

CASE REPORT - 1 CLINICAL PHOTOS

PREOPERATIVE PICTURE SHOWING DEFECT WITH EXPOSED EXTENSOR TENDON.

INTRAOPERATIVE PICTURE

PICTURE AFTER FLAP INSET

POST OPERATIVE PICTURE AFTER ONE MONTH

CASE REPORT - 2 CLINICAL PHOTOS

PREOPERATIVE PICTURE WITH EXPOSED TENDONS

INTRAOPERATIVE PICTURE AFTER FLAP INSET

INTRAOPERATIVE PICTURE

POST OPERATIVE PICTURE

CASE REPORT-3

45/M a right handed individual auto driver by occupation presented with post traumatic soft tissue defect involving the left thumb stump following traumatic amputation at the level of interphalangeal joint. H e presented to our department about one week after injury. Wound debridement was done and planned for littler neurovascular island flap from ulnar aspect of middle finger to provide a stable sensate cover. Under tourniquet contol pattern of defect made and flap harvested preserving the neurovascular pedicle and transposed to cover the defect. Postoperatively patient was educated about reorientation of sensation to thumb from middle finger. Donor area had some skin loss which eventually healed by secondary intention.

CASE REPORT-4

31/M A right handed individual electrician by occupation presented with post traumatic soft tissue defect over the tip of left thumb. He has sustained the injury one day back and was referred from private hospital. On examination there was skin and pulp loss exposing the tip of distal phalanx. Xray showed no underlying fracture. He was planned for local flap using kutler flap. Kutler flap raised and advanced to cover the finger tip. Flap settled well.

CASE REPORT - 3 CLINICAL PHOTOS

PREOPERATIVE PICTURE

INTRAOPERATIVE PICTURE

IMMEDIATE POST OPERATIVE PICTURE ON DAY TWO

POST OPERATIVE PICTURE AFTER TWO WEEKS

CASE REPORT - 4 CLINICAL PHOTOS

PREOPERATIVE PICTURE SHOWING THUMB TIP INJURY

IMMEDIATE POST OPERATIVE PICTURE

POST OPERATIVE PICTURE

CASE REPORT-5

58/M Presented with injury to his right little finger six hours after injury. He was a right handed individual. Xray showed fracture of the terminal phalanx tuft with nail avulsion and transverse amputation of the finger tip region. Atasoy V-Y advancement flap was marked, flap raised and anchored to the remaining intact nail bed. Flap survived with good sensation.

CASE REPORT 6

32/M A right handed individual presented with post electrical burn scar contracture involving the volar surface of right index, middle, ring and little finger, causing flexion deformity. Xray done to rule out secondary joint pathology. Z plasty was used to release the contracture involving the little, ring and index finger and simultaneously cross finger flap from the dorsum of ring finger used to cover the volar surface of the middle finger. Flap settled well and division was completed after 14 days. Graft take was 100 percent. Post operatively physiotherapy was started immediately after the flap settled and range of movements was good.

CASE REPORT - 5 CLINICAL PHOTOS

PREOPERATIVE PICTURE SHOWING FINER TIP INJURY

XRAY SHOWING FRACTURE OF TERMINAL PHALANX

INTRAOPERATIVE PICTURE

AFTER FLAP INSET

DORSAL VIEW

POST OPERATIVE PICTURE AFTER 4 DAYS

CASE REPORT - 6 CLINICAL PHOTOS

PREOPERATIVE PICTURE SHOWING BURN CONTRACTURE

INTRAOPERATIVE PICTURE SHOWING Z PLASTY AND CROSS FINGER FLAP

POST OPERATIVE PICTURE- PALMAR VIEW

POST OPERATIVE PICTURE- DORSAL VIEW

CASE REPORT 7

30/M presented a year later after burns involving left hand. On examination there was contracture involving the PIP and MCP joint of left hand fingers except thumb. Scar was excised. K wire fixation done to maintain fingers in extension. Defect pattern marked. Ipsilateral groin flap elevated and transposed to cover the soft tissue defect over the palmar surface of the fingers. . Flap division was done after 21 days. Flap was healthy after division.

CASE REPORT 8

48/M A right handed individual presented with post traumatic soft tissue defect over the right thumb extending from the tip to the base. He sustained the injuries in the work place. Radigraphy revealed no fractures. To provide a sensate tip to the thumb tip neurovascular island flap from ulnar aspect of middle finger was raised and tunneled to cover the defect. Donor area was skin grafted. Flap settled well and patient was educated about cortical reorientation of sensibility.

CASE REPORT - 7 CLINICAL PHOTOS

PREOPERATIVE PICTURE

PREOPERATIVE PICTURE DORSAL VIEW

INTRAOPERATIVE PICTURE

IMMEDIATE POST OPERATIVE PICTURE

PICTURE AFTER FLAP DIVISION

CASE REPORT - 8 CLINICAL PHOTOS

PREOPERATIVE PICTURE

INTRA OPERATIVE PICTURE

POSTOPERATIVE PICTURE

POST OPERATIVE PICTURE AFTER 2 DAYS

ANALYSIS OF RESULTS

Of the 30 cases operated, most common cause was due to trauma followed by infection and burns. Of the traumatic causes, road traffic accidents was the major cause followed by industrial and then agricultural work spot injuries. Most of the cases required option beyond simple skin grafts indicating the fact that most injuries were associated with exposure of deep structures requiring flap cover.

Also distant flaps were required in more cases than local flaps indicating the severity the hand is subjected to injury, making local flaps unavailable for reconstruction.

Regional flaps has been used in 3 cases. Posterior interosseous flap in 2 cases and reverse radial forearm flap in one case.

We did not get cases of such type requiring free microvascular flaps.

Of all the local, regional and distal pedicle flaps only two flaps showed distal tip necrosis. One was a case of atosay v-y advancement flap and the other was posterior interosseous flap, and the raw area healed with secondary intention. One case of littler neuro vascular island

flap got infected with abcess formation along the tunnel for the pedicle extending on to the donor site. Luckily the flap survived but there was minimal graft loss at the donor site, which was allowed to heal by secondary intention.

Skin graft loss was found in less than 5percent of cases grafted. Post operatively mobilization was started as soon as the graft and flaps settled. Follow up of the patient was done for 3 to 6 months and secondary reconstruction of tendon, bone done if needed.

Functional results were evaluated using pinch grip, tripod grip, power grip and hook grip.

Aesthetic results evaluated by colour match, texture match, correction of contour deformity and donor site morbidity. Colour and texture match were better with local than regional flaps and distant flaps. Pigmentation and contour correction was poorer with skin grafts compared to local flaps.

CONCLUSION

The tissue on the dorsum of hand is nonglabrous, thin and mobile to allow individual movements of joints of hand. The thin layer of areolar tissue covering the tendons permits motion and tendon gliding. For dorsal wounds with intact areolar tissue covering the tendons, full thickness skin grafts are preferred for coverage. Protective sensation is often achieved as a result of ingrowth of dorsal sensory nerves into the graft.

Flap coverage is required when vital structures such as vessels, nerves, tendons or bone is exposed. Flaps are necessary if secondary surgery such as bone grafts, nerve grafts, or tendon transfer is to be performed. A soft tissue flap provides durable coverage, including skin and subcutaneous tissue. Subsequent elevation of the flap for secondary procedures such as tendon or bone grafts can be readily accomplished. Although thickness of subcutaneous tissue is variable, the application of this flap to the upper extremity does not alter the normal contour of the recipient site. In contrast the thickness of a musculocutaneous flap is often excessively bulky when used in the reconstruction of the dorsal hand. Similarly use of muscle and skin graft eliminates the subcutaneous tissue, which might be excessive in obese patients. Application of skin

graft over vascularized fascia provides the thinnest coverage and is often desirable over the dorsal surface of hand.

Reconstruction should aim at all the structural and functional components of the hand. The surgeon should analyze the deficiency properly and should outline the appropriate and correct reconstructive plan. Thus it is important to understand the unique aspects of skin coverage of upper extremity.

The cosmetic aspect of reconstruction in upper extremity should be addressed carefully, in addition to the functional reconstruction.

Closure of defect should begin with an analysis of the wound, its surrounding environment and development of the reconstructive plan.

Typically, the simplest possible option that accompanies the reconstructive goals is the best choice. Local skin has qualities that are are similar to those of the skin lost and therefore is the most desirable means of providing coverage. This should be considered if the defect is relatively small and there is adequate mobile tissue in the area that can be recruited to close the defect with minimal tension.

Next in complexity is a simple skin graft. In the hand however, when defects are n not suitable for these simple options, because there is not enough surrounding tissue laxity, there are exposed vital structures, or the resulting scar would be less than ideal cosmetically or functionally, other options should be looked for.

Local transposition flaps including rhombic flaps of Limberg and Duformental are extremely useful throughout the hand and are the most common type of flap used in hand. Atosay, kutler flap are useful for finger tip injuries, while moberg palmar advancement flap is useful for thumb tip injuries.

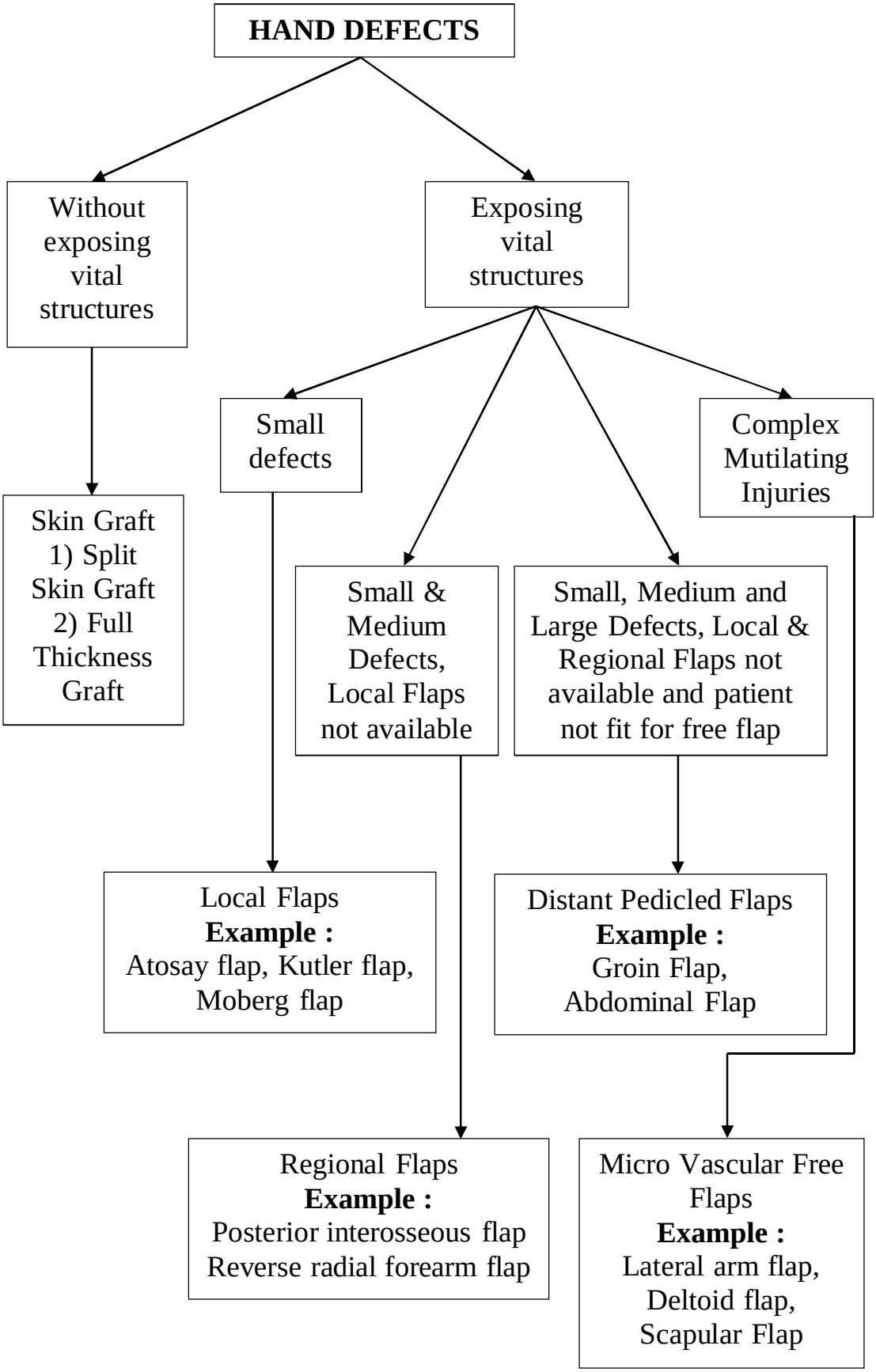
Distant pedicled flaps including random pattern flaps from chest, abdomen axial pattern cutaneous flaps from groin are very useful option and effective in covering small, medium, and large defects of hand and upper extremity and provide an excellent alternative to other forms of reconstruction. All these flaps require two stage transfers and are cumbersome to work.

The radical option is a free tissue transfer. This option should be reserved for those situations in which no good local options exist. It may well be worth the time effort and risk for the benefit of bringing well

vascularized, healthy supple skin and subcutaneous tissue into defect. Tendon, nerve, bone, joints also can be transferred successfully using this versatile technique.

Reconstruction should aim to replace all structural and functional components of the hand. Ideally, soft tissue defects of hand should be replaced with similar tissue. Local or free flaps are excellent options. However they must provide with sufficient subcutaneous tissue for deep gliding structures, supply subcutaneous tissue in bulk for coverage of vital neural, vascular, bone and joint structures, and be aesthetically pleasing. Finally surgeon should also choose the proper composite flap for reconstruction of a complex tissue defect.

ALGORITHM


HAND DEFECTS
Without exposing vital structures
Exposing vital structures
Skin Graft 1) Split Skin Graft 2) Full Thickness Graft
Small defects
Complex Mutilating Injuries
Small & Medium Defects, Local Flaps not available
Small, Medium and Large Defects, Local & Regional Flaps not available and patient not fit for free flap
Local Flaps
Example :
Atosay flap, Kutler flap, Moberg flap
Distant Pedicled Flaps
Example :
Groin Flap, Abdominal Flap
Regional Flaps
Example :
Posterior interosseous flap
Reverse radial forearm flap
Micro Vascular Free Flaps
Example :
Lateral arm flap, Deltoid flap, Scapular Flap

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PROFORMA

Name-

Age-

Sex-

Occupation-

Handedness-

Town-

H/O Present complaints-

H/O Comorbid illness-

General Examination-

Examination of hand

Location of defect-

Size of defect-

Asociated nerve, tendon, vascular injury-

Exposed tendon, nerve, vessel

Vascular status

Degree of contamination

Investigations

Complete hemogram

Blood sugar, urea, serum creatinine

Xray hand& wrist

Management plan

Wound debridement and proceed

Complications

MASTER CHART

S. No.	Age	Sex	Mode of defect	Area involved	Option used
1	26	M	Traumatic	Dorsum hand	Skingraft
2	45	M	Infective	Middle finger volarsurface	Cross finger flap
3	47	F	Burn	Ring finger volarsurface	Skingaft
4	20	M	Traumatic	Dorsum hand	Groin flap
5	58	M	Traumatic	Little finger tip	Atosay flap
6	24	F	Infective	Dorsumhand	Abdominal flap
7	25	M	Traumatic	Dorsumhand	Skingraft
8	19	F	Burn	1 web space	Groin flap
9	50	M	Traumatic	Dorsum hand	Posterior interosseous flap
10	42	M	Traumatic	Dorsum and palmar mutilation	Groin flap
11	10	M	Burn	Dorsum	Skingraft
12	31	M	Traumatic	Thumb tip	Kutler flap
13	33	F	Infective	Middle finger volarsurface	Crossfinger flap
14	15	M	Traumatic	Web space and dorsum	Groin flap
15	58	F	Infective	Middle finger volarsurface	Crossfinger flap
16	24	M	Burn	Palmar surface	Abdominal flap
17	37	M	Traumatic	Dorsumhand	Skingraft
18	12	F	Infective	Dorsumhand	Groin flap
19	32	F	Traumatic	Dorsumhand	Posterior interosseus
20	46	M	Traumatic	Volar mutilating injury	Groin flap
21	27	M	Burn	Dorsum hand	Groin flap
22	44	F	Traumatic	Dorsumhand	Skingraft
23	30	M	Burn	Dorsumhand	Abdominal flap
24	29	F	Infective	Ringfinger volarsurface	Crossfinger flap
25	38	M	Traumatic	Dorsumhand	Reverse radial forearm flap
26	33	F	Infective	Finger extensor aspect	Hypogastric flap
27	45	M	Traumatic	Thumb pulp defect	Litler neurovascular island flap
28	52	M	Traumatic	Dorsum hand	Abdominal flap
29	28	F	Traumatic	Dorsum hand	Skingraft
30	35	M	Traumatic	Dorsum hand	Skingraft