A COMPARATIVE STUDY TO ASSESS THE FUNCTIONAL AND AESTHETIC OUTCOME OF SINGLE STAGE RECONSTRUCTION WITH STAGED OSTEOPLASTIC RECONSTRUCTION OF THUMB – A RETROSPECTIVE AND PROSPECTIVE STUDY

Dissertation submitted to

THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY

In partial fulfillment of the regulations

for the award of the degree of

MCh Branch – III

PLASTIC AND RECONSTRUCTIVE SURGERY

INSTITUTE FOR RESEARCH AND REHABILITATION OF HAND

AND

DEPARTMENT OF PLASTIC SURGERY

CHENNAI - 600 001

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CERTIFICATE

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–A RETROSPECTIVE AND PROSPECTIVE STUDY

Certified that this dissertation is a bonafide work of **Dr.G.VISHNU BABU**, Post Graduate in M.Ch.Plastic and Reconstructive Surgery during 2009 – 2012 at the Institute for Research and Rehabilitation of Hand and Department of Plastic Surgery, Govt.Stanley Medical College. This study was done under my supervision and guidance.

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DECLARATION

I solemnly declare that this dissertation titled ". A COMPARATIVE STUDY TO ASSESS THE FUNCTIONAL AND AESTHETIC OUTCOME OF SINGLE STAGE RECONSTRUCTION WITH STAGED OSTEOPLASTIC RECONSTRUCTIONOF THUMB –A RETROSPECTIVE AND PROSPECTIVE STUDY- is done by me in IRRH and Department of Plastic Surgery, Stanley Medical College & Hospital , Chennai under the guidance and Supervision of Prof.J.Mohan, M.S., M.Ch., Professor & Head of the Department, IRRH and DPS Stanley Medical College, Chennai. This dissertation is submitted to the Tamil Nadu Dr.MGR Medical University,

Chennai in partial fulfillment of the university requirements for the award of the degree of M.Ch. Plastic and Reconstructive Surgery.

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INDEX

INTRODUCTION

The presence of an opposable thumb has provided man with unique functional capability. Daily tasks involving pinch, grasp, grip and precision handling are more easily accomplished with an opposable thumb. Congenital absence or hypoplasia, traumatic loss diminishes or eliminates the thumbs prehensile abilities and may affect overall hand function.

The loss of the thumb alters the aesthetic symmetry of the hand and can result in up to 40% impairment of hand function. Hence significant interest has been developed all over the world, during the years in the development of various methods of thumb reconstruction.

Various methods have evolved over the years; the following methods have emerged as the preferred ones:

1. Osteoplastic reconstruction of thumb using skin cover, bone graft and a digital neurovascular island flap.
2. Single stage reconstruction of thumb using available local and regional flaps, bone graft and a digital neurovascular island flap.

3. Pollicization of index finger.
4. Microsurgical reconstruction using great toe or second toe.

Hence management of patients with thumb loss requires sound clinical evaluation and judgment in regard to treatment plan and excellent surgical technique required to get good functional outcome of the hand.

AIM OF THE STUDY

To compare the functional and aesthetic outcome of single stage thumb reconstruction with staged osteoplastic reconstruction of thumb.

MATERIALS AND METHODS

This is a retrospective and prospective study done between the period of January 2011 to January 2013 at our institution.

16 patients were taken up for the study in each group and compared the functional and aesthetic outcome of each procedure.

Functional assessment was done at 6 months in each group.

Multiple surgeons were involved in reconstruction.

Inclusion criteria :

All patients with thumb loss distal to MP Joint who underwent single staged thumb reconstruction or osteoplastic reconstruction.

Exclusion criteria:

Patient not willing for single staged reconstruction underwent other methods of thumb reconstruction.

HISTORICAL BACKGROUND ON THUMB RECONSTRUCTION

Thumb reconstruction begins with deepening of the first web space to increase the length of a partially amputated thumb by **Hugie**r[3] in 1874 and it was named phalangization by **klapp** in 1912.

In 1887, **Guermonprez**[11] first suggested transferring an index or other finger of the same hand into the thumb position following traumatic loss.

In 1897, **Nicoladoni**[4-6] described the osteoplastic method of thumb reconstruction, he also performed pedicled great toe transfer for reconstruction of thumb following traumatic amputation.

In 1903, **Luksch**[13] was the first to describe staged pedicled transfer of the index finger of the opposite hand.

In 1918, **Joyce**[13] utilized a contra lateral ring finger for thumb reconstruction.

In 1949 Gosset[16] and 1952 **Bunnel**l[17] was described the island pollicization of the index finger but the distal skeleton was amputated to obtain the ideal length.

In 1950 **Hilgenfeldt**[15] described the pollicization of the middle finger.

In 1946 **Arthur Murray**[18] during World War II, was the first to describe the classic pollicization method, and it was popularized by littler (1952), **Moberg**[21] (1955) and **Buck-Gramcko**[22] (1971).

In 1957 **Gilles**[7] described the “cocked hat” flap which resurrected the osteoplastic thumb reconstruction, as sensory input could now be reconstructed.

Biemer and **Foucher**[32] described two methods of single stage thumb reconstruction utilizing composite radial osteocutaneous forearm island flaps.

In 1960 **Littler**[8] described the neurovascular island flap and this further added the enthusiasm for this technique.

In 1967 Ivan matev[23] of Bulgaria was first described the distraction of 1st metacarpal to lengthen the thumb.

In 1968 Cobbett[10] of England reported a case of free transfer of a great toe to replace the amputated thumb.

In 1980 Leung of china described the restoration of thumb function by second toe transfer.

In 1980 O'Brien[27] and Morrison[28,29] reported on thumb reconstruction utilizing a free neurovascular 'wrap-around flap' from big toe.

GOALS OF THUMB RECONSTRUCTION

The key factors that determine the success of a reconstructed thumb was described by Littler[34] are

1. stability
2. strength
3. mobility
4. length
5. sensibility
6. Aesthetic appearance

The reconstructive surgeon aspires to reconstruct the ideal thumb replacing ‘like for like’ and restoring both form and function.

Heitmann and Levin[35] outlined the goals of reconstruction are

1. Stability at joints
2. Adequate strength to resist the forces of fingers
3. Sensate and non tender thumb
4. Correct positioning of the thumb with a wide web space

5. Mobility of the Carpometacarpal joint with intrinsic muscles to aid prehension

It is important to provide painless, durable skin cover with atleast protective sensation.This is critical as the degree of thumb dysfunction may appear out of proportion to the anatomical defect.

A manual worker may opt for stability and power, while a pianist may opt for sensation and mobility, similarly length may be important to patients performing fine motor tasks.

The thumb has prehensile and non-prehensile functions. The two important prehensile functions of the thumb are power grip and precision grip. Power grip is achieved with the thumb in adduction and flexion, the key muscle is adductor pollicis.

Precision grip allow us to grasp and manipulate small objects and perform delicate functions with our hands. This is achieved with the thumb in abduction and opposition.

A tip-to-tip pinch is used for fine activities, while a pulp-to-pulp pinch is used if more force is needed. If even greater force needs to be applied, the middle finger pulp participates forming a three point pulp-to-pulp pinch or chuck grip.

The key non-prehensile functions of the thumb are support, sensation and appearance.

The sensory function of the thumb has been emphasized earlier and one criterion of any successful thumb reconstruction is restoration of sensation.

What appears to be functional reconstruction from the surgeon's point of view by staged osteoplastic method of thumb reconstruction may not be appreciated by the patient for it's physical appearance.

RELEVANT ANATOMY

SKIN

The thumb has specialized glabrous skin over the volar surface with a unique subcutaneous pulp padding and stability with a higher density of nerve endings and eccrine sweat glands, but no sebaceous glands. Skin on the ulnar aspect of the terminal phalanx has the greatest cortical sensory representation and also contains mobile pulp required for picking-up small objects. All specialized features are present in the terminal phalanx; hence amputation closure at IP joint level will lack much of thumb function even if adequate length is preserved.

THE WEB

First web in full abduction shows a well defined crest, the palmar and dorsal walls of which are covered with glabrous skin. It allows better gripping that participates in grasping of objects. The loss of working ability of the thumb due to loss or contracture of the web space is equivalent to amputation of the thumb.

THE MUSCULATURE

Movement of the thumb are produced by two group of muscles, the extrinsic muscles (flexor pollicis longus, abductor pollicis longus, extensor pollicis brevis and extensor pollicis longus) and the intrinsic muscles (abductor pollicis brevis, opponens pollicis, flexor pollicis and adductor pollicis). First dorsal interosseous also play a role in thumb motion. Adductor has a force that is greater than the combined force of the remaining three thenar intrinsic. Intrinsic muscles form a cone surrounding the first metacarpal and these are innervated by radial, median and ulnar nerves.

FIRST METACARPOTRAPEZIAL JOINT

The metacarpotrapezial joint is described as ‘a double saddle joint where the concavo-convex articular surface of one bone is reciprocally homomorphic with the convexo-concave surface of the other’. The joint is accurately described as one saddle atop another, with three degrees of motion:1. Flexion-extension, 2.abduction-adduction: and 3.medial rotation-lateral rotation.

The base of the first metacarpal has a quadrilateral articular surface which is a complimentary match to the articular surface of the trapezium. Stability and close co-aptation of the joint surface between the trapezium and the

first metacarpal, is dependent upon the presence of operational muscles and tendons. There is a lot of slack in the joint capsule allowing a wide range of motion including joint distraction of up to 3 mm.

An important stabilizing capsular ligament is the anterior oblique carpometacarpal ligament, it retains the fragment of bone fractured free from the base of the metacarpal as the metacarpal displaces radially in Bennett's fracture.

The ligament at the radial border of the joint is dorsoradial or anteroexternal ligament. It forms part of the joint capsule and attaches to the anterior crest of trapezium. Dorsally, posterior oblique ligament crossing the dorsal joint capsule from the radially positioned posteroexternal position of the trapezium to attach to the ulnar base of the first metacarpal. Intermetacarpal ligament and anterior oblique ligament prevents radial subluxation of the metacarpotrapezial joint.

METACARPOPHALANGEAL JOINT

Range of motion is less than other finger metacarpophalangeal joints. The metacarpal and proximal phalanxes are stouter to accommodate the greater forces normally borne by the thumb in pinching and grasping.

The head of the first metacarpal is different because the radial articular surface of the proximal phalanx is fashioned reciprocally to match.

The collateral ligaments are similar to other metacarpophalangeal joints. Some pronation but no supination is allowed at the metacarpophalangeal joint when it is in extension. In supination, the joint locks into a stable position for secure grasping. The fibrocartilaginous palmar plate extends from the palmar base of the proximal phalanx to the neck of the metacarpal. It regularly incorporates two sesamoid bones.

THE INTERPHALANGEAL JOINT

The interphalangeal joint has one degree of freedom- flexion and extension. The tip rotates into a perceptible degree of pronation. Normal thumb flexion approaches 90'. The combination of pronation at the metacarpotrapezial joint and at the interphalangeal joint augments the major motion of abduction, flexion and pronation at the metacarpotrapezial joint to achieve approximate of the pulp of the thumb with pulp of other fingers.

BLOOD SUPPLY

The first metacarpal artery is the prime source of blood supply to the radial and ulnar proper digital arteries of the thumb, and the radial proper digital artery of the index finger, which arises from the deep arch formed by radial artery. These digital arteries also receive collateral branches from the superficial palmar arch as well.

The dorsal metacarpal arteries arise from dorsal carpal arch and extend distally to the margins of the fingers. Dorsal arteries to the thumb also came from the branches of the radial artery before it plunges through the first dorsal interosseous arcade.

Venous drainage is through the superficial and deep venous system. Arteries of the thumb are accompanied by paired venous commitantes which constitute the deep venous system. Superficial venous system drains via dorsal metacarpal vein into cephalic venous system.

SENSORY SUPPLY

Glabrous skin of the thumb is innervated by radial and ulnar digital nerves, derived from the median nerve. Dorsal aspect of the thumb is innervated by dorsal branches of the superficial radial nerve.

FACTORS AFFECTING METHOD OF THUMB RECONSTRUCTION

The key factors are

1. Level of injury
2. Age, occupation, general condition of the patient
3. Status of the other fingers
4. Condition of thenar musculature

The level of injury is the most important deciding factor in selecting the most appropriate reconstructive procedure.The choice of reconstruction depends on the skin defect and also depends on the need and desires of the patient.

Classification described by Kleinman and Strickland followed for thumb reconstruction are dividing the thumb into thirds

a. Amputation at distal phalangeal level
b. Amputation at proximal phalangeal level
c. Amputation at metacarpal level

SINGLE STAGE THUMB RECONSTRUCTION

The ultimate goal of single stage reconstruction is to provide pain free stable thumb with adequate length, which is achieved by using either native bone if available or used ulnar bone graft and covered with neurovascular island flap on the volar side and first dorsal interosseous artery flap or posterior interosseous flap on the dorsal side. This method is used to reconstruct the thumb amputations at or distal to the metacarpophalangeal joint. In patients not willing for (i)toe transfer (ii)staged osteoplastic reconstruction or (iii) metacarpal lengthening, the preferred method is single stage reconstruction .

FLAPS USED FOR SINGLE STAGE RECONSTRUCTION

The following combination of flaps were used for reconstruction are

1. First dorsal metacarpal artery flap with neurovascular island flap
2. Posterior interosseous artery flap with neurovascular island flap
3. Double neurovascular island flap

STEPS FOLLOWED IN SINGLE STAGE RECONSTRUCTION

1. Preparation of available native bone or ulnar bone graft harvest
2. Harvesting of First dorsal metacarpal artery flap or Posterior interosseous artery flap
3. Harvesting of neurovascular island flap
4. Fixation of bone graft
5. Flap inset

BONE GRAFT PREPARATION OR HARVEST

If the patient had brought the amputated part in a well-preserved manner and if the same was not fit for replantation, then the bone from the amputated part was harvested and used to reconstruct the thumb. Otherwise ulnar bone graft was used. The other bone sources of bone graft is iliac crest but our choice is the ipsilateral ulna.

PROCEDURE

A vertical incision of three to four inches was made over the posterior border of upper end ulna. The incision was deepened through subcutaneous tissue, deep fascia was incised. The muscle origins on either side are dissected leaving the periosteum intact. The required length of bone graft which was previously assessed based on the size of the contralateral thumb was marked with ink. Bone was harvested using an osteotome or electrical saw. The

osteotomes are introduced all around the marked graft in a step ladder pattern and this elevates the bone graft completely with a thin layer of cancellous bone.

Donor bone defect was covered with bone wax and the muscles were approximated over the bone with 3-0 vicryl and skin closed with 3-0 nylon with a drain in place.

The advantages are

1. Single anesthesia (axillary block) is sufficient for the entire procedure
2. Good cortical bone with periosteum of adequate length can be harvested with a thin layer of cancellous bone.
3. Resorption rate is lower and can with stand the stress as well.
4. Low donor site morbidity and camouflauging of scar.
5. Patient can be mobilized on first postoperative day and which is not possible in iliac bone graft patients

FIRST DORSAL METACARPAL ARTERY FLAP

The first dorsal metacarpal artery flap (FDMA) is an axial pattern flap based on the first dorsal metacarpal artery and its terminal dorsal digital branches, and it is harvested from the skin of the dorsal surface of the proximal

phalanx of index finger. This flap is mainly used as a sensory flap for coverage of skin on the dorsum of the thumb by including the dorsal digital branch of superficial branch of radial nerve.

This flap is marked on the dorsum of the index proximal phalangeal region from the Proximal Interphalangeal to the MetaCarpo Phalangeal joint. The pedicle is dissected to include the interosseous fascia with the branches of the FDMA, as well as the superficial radial nerve, and its accompanying artery. The latter is exposed through a dorsal S-shaped incision starting from the base of the first interosseous space, and ending at the proximal edge of the flap. The skin over the interosseous space is dissected just deep to the dermis, to include the dorsal veins and terminal branches of the radial nerve in the flap pedicle.

The flap is raised from distal to proximal at a plane superficial to the extensor paratenon. A constant perforator coagulated at the neck of the metacarpal bone, and the interosseous fascia is released from the metacarpal bones. The pedicle length can reach 7 cm in an adult, thus allowing wide arc of rotation. A wide subcutaneous tunnel is dissected, and the flap is tunneled without twisting the pedicle into the primary defect. . Flap is sutured in place. The dorsal incisions are closed. The donor defect is resurfaced with a free graft.

LITTLER'S NEUROVASULAR ISLAND FLAP

The patency of both digital vessels of the donor finger is confirmed by performing finger Allen's test before raising the flap. The flap is marked on the ulnar side of middle finger over middle phalangeal region. Larger dimension of flap can be harvested in the middle finger when compare to other finger and has the same median nerve innervation. Neuro vascular island flap should be harvested of adequate size to cover the entire native bone or ulnar bone graft. This is achieved by most volar edge of the flap should be digital volar midline. Darts are made at the interphalangeal flexion creases to prevent flexion contracture.

The most dorsal edge of the flap should be determined by the flap size requirements and may extend to the dorsal digital midline, without darts. The palmar incision radiate in a zigzag fashion from the central palm to the bases of the flap. Dissection begins in the palm. The common digital artery and the nerve to the flap are identified. At the bifurcation to proper digital arteries, the proper digital artery to the adjacent finger is isolated. Care must be taken to avoid skeletonizing the digital artery and nerve and carry the small vein- bearing soft tissue loosely attached around them. After the initial palmar dissection has verified suitability of the neurovascular anatomy for transfer, the margins of the flap are incised. The flap is elevated by sharp dissection from its distal end proximally, leaving the thin areolar layer over the extensor tendons and flexor sheath. It will be necessary to isolate, divide, and

ligate the transverse –oblique vincular and articular branches of the digital artery at each interphalangeal joint. The dorsal branch of the proper volar digital nerve is preserved with the flap.

On reaching the proximal end of the flap, the nerve-vessel pedicle is dissected into the palm, preserving the adherent fatty areolar tissue. The identity of the proper digital artery to the adjacent finger is reconfirmed, and this vessel is then ligated and divided, freeing the common digital artery as well as several small branches. The proper digital nerve is carefully separated from the common nerve by epineural incision using loupe magnification. The digital nerve and artery with their attendant areolar tissue investment are thus mobilized to the central palmar pivot point from the superficial arch. Subcutaneous pocket is created adequately between the palmar rotation point and the primary defect in order to prevent compression during tunneling. Palmar fascia can be cut to avoid kinking or pedicle compression at the pivot point. Flap is tunneled into the primary defect without torsion; viability of flap should be confirmed after tunneling. Flap is sutured in place. The palmar and digital incisions are closed. The donor defect is resurfaced with a split skin graft.

POSTERIOR INTEROSSEOUS ARTERY FLAP

The posterior interosseous artery flap is raised as a distally based pedicled axial pattern flap with reverse blood flow based on the communication between anterior and posterior interosseous artery at the extensor aspect of distal forearm.

The elbow is positioned in full pronation and 90’ of flexion. Surface markings indicate the lateral epicondyle and inferior radio-ulnar joint. The point at the junction between the proximal and distal third marks the emergence of the PIA in the dorsal extensor compartment; this is 7.5 to 9.5 cm distal to the lateral epicondyle. Flap design should not extend more than 3cm proximal to this point.

The flap is outlined, depending on the size of the defect. For flap siting, it is wise to continue the distal margin of the design beyond the midpoint of the epicondyle –ulnar line, to include the constant perforator. The distal incision is extended just to the level of deep fascia. The septum between the extensor carpi ulnaris and extensor digiti minimi is identified, and the fascia incised on either side of the septum.

The PIA is identified, and the communication with the anterior interosseous artery, after retraction of the extensor indicis proprius tendon, is verified. The septum containing the artery and its perforators is dissected proximally to the skin paddle, by retracting the extensor carpi ulnaris medially and the extensor digiti minimi and extensor indicis proprius to the radial side. The skin paddle incision is carried through the level of the fascia, and

an extra 1cm of fascia is included circumferentially. To avoid shearing forces between the skin and the fascia, fine absorbable stitches are used to fix the fascia to the skin. The skin paddle itself is raised with the fascia, beginning with dissection on the radial side over the wrist extensor, and more ulnarly over the common finger extensors.Under loupe magnification, the PIA is isolated from the branches of the posterior interosseous nerve and PIA should be ligated distal to the nerve. The ulnar side of the skin paddle is then raised, and the pedicle itself is dissected off the ulnar shaft. Subcutaneous tunneling should be made between the pivot point and the primary defect. Flap is tunneled into the primary defect. Sub dermal skin flap sutured with 3-0 nylon and donor site covered with free graft.

BONE GRAFT FIXATION AND FLAP INSET

The bone graft is fixed proximally in base of proximal phalanx or head of the first metacarpal by pegging. Once the stability of the bone is achieved, neurovascular island flap and first dorsal metacarpal artery flap or posterior interosseous artery flap are sutured together to cover the bone graft.

Bulky dressings are given with dorsal plaster splint and a window is created to monitor the flap postoperatively.

POST-OPERATIVE PROTOCOL

The donor site skin graft was inspected on the fifth postoperative day. All the sutures were removed on tenth day and started mobilization of donor finger to prevent stiffness and graft massage to prevent secondary contracture of the finger. The thumb splint was retained for three more weeks for bone healing.

COMPLICATIONS

1. Vascular compromise of one of the flap may occur.
2. Donor site graft loss
3. Stiffness of PIP joint of index or middle finger
4. Displacement of free bone graft
5. Palmar incision contracture.

ADVANTAGES

1. Single stage procedure
2. Regional anaesthesia is sufficient to do the procedure.
3. Early mobilization of thumb is possible at CMC joint.
4. Early return to work is possible because of single staged reconstruction.
5. Cost effective
6. It does not require technical expertise or microsurgical facility for reconstruction.

DISADVANTAGES

1. Patient does not have IP joint motion
2. Nail complex is not present.
3. Donor site morbidity in PIA flap
4. Delayed sensory reorientation

OSTEOPLASTIC METHOD OF THUMB RECONSTRUCTION

This method of reconstruction requires two stages. In the first stage tubed groin flap wasdone and in the second stage osteoplastic reconstruction by free ulnar bone graft with neurovascular island flap has been done.

This procedure done in amputations at or distal to the MCP joint. The stump should be mobile with intact CMC joint and intrinsic muscles of the thumb. This method of reconstruction does not required technical expertise or infrastructure for microsurgical reconstruction. This is the procedure of choice in patient not willing for toe transfer or when other fingers are injured.

FIRST STAGE

GROIN FLAP

Groin flap is an axial pattern flap based on the superficial circumflex iliac artery, which originates from the common femoral trunk 2-3 cm under the crural arcade. From this origin , the artery runs beneath the deep fascia as far as the medial border of the Sartorius muscle, and then subcutaneously in an oblique course, parallel to the inguinal ligament, to reach the anterior superior iliac spine.

In designing the flap, the femoral artery, the arcade and the borders of the Sartorius muscle are drawn on the inguinal skin, and the course of the superficial circumflex iliac artery is marked . The pattern of the flap may then be correctly situated and traced.

The dissection starts at the distal lateral border of the flap exactly between fat and aponeurosis, as far as the lateral border of Sartorius, where the superficial fascia of the muscle is incised and elevated on the deep surface of the flap, protecting the vessels. Then it is tubed in such a way that the seam lies in the centre of the volar side to accommodate the proposed neurovascular island flap. Before the flap inset, donor site closed primarily in two layers. Flap inset given with 3-0 nylon. On tenth day sutures was removed. Flap division and inset given at three weeks.

SECOND STAGE

Osteoplastic reconstruction usually performed 2 to 3 months after the first stage.

BONE GRAFT AND LITTER'S ISLAND FLAP HARVEST

As previously stated that the method of harvest of free ulnar bone graft and littler's Neurovascular Island flap. Used in osteoplastic reconstruction of thumb in second stage.

THUMB LENGTHENING PROCEDURE

Lengthening technique may be either one stage or progressive. one stage technique described by Buck-Gramcko, who stressed the necessity of mobilization of muscle origins to facilitate perioperative distraction. Simultaneous web deepening can be performed. One of the major drawbacks is the limitation of lengthening to 12 to 25 mm and the necessity of a strong fixation by a plate.

The progressive distraction by Matev is a multiple-stage operation that includes an osteotomy with insertion of an exfixator allowing progressive lengthening. After a weak to allow skin healing, a 1 to 2 mm lengthening is provided each day, as determined by pain, distal skin blanching, and pin tolerance.

When a periosteal sleeve is preserved, to avoid grafting, a slow pace is adopted (1mm/day) to allow callus formation; otherwise faster pace can be used. After desired is obtained, a bone graft has to be inserted. It is better to allow full “expansion” of the soft tissues and to avoid loss of too much length when the bone graft is interposed. Such lengthening is performed at metacarpal level, but we found advantages in performing at the phalangeal level when possible. Phalangeal level avoids the pitfalls of the intrinsic muscle traction and web deepening. A 100% lengthening is possible in children and in adults at the phalangeal level rarely obtained at the metacarpal level in adults. The indications for distraction lengthening arise from contraindications to other methods or unwillingness of the patient for other procedures.

FUNCTIONAL ASSESSMENT

MOTOR ASSESSMENT

In both the groups, each patient range of movements were assessed at CMC joint of thumb. The movements assessed were

1. Flexion
2. Extension
3. Adduction
4. Abduction
5. Opposition

Clinically assessed the thumb web in all the patients and any contracture was recorded.

In order to evaluate opposition, kapandji's grading[39] system was followed. This method does not require measurement of angles. Hand itself is used as the system of reference. Opposition is tested by Kapandji's grading system.

Scoring was done as follows:

1. Radial side- proximal phalanx of the index finger
2. Radial side-Middle phalanx of the index finger
3. Index finger tip
4. Middle finger tip
5. Ring finger tip
6. Little finger tip
7. Touching of little finger DIP joint crease
8. Touching of little finger PIP joint crease
9. Little finger proximal crease
10. Touching of distal crease of the palm

GRADING

Scores 6-10- good

3-5- fair

1-2- poor

POWER GRIP MEASUREMENT

Jamar dynamometer was used to measure the power grip in both group of patients. Recordings were taken from both normal and reconstructed hand thrice alternatively. Calculation of the mean and percentage was done and compared with the normal hand.

Measurement using grip dynamometer was done with full flexion of the fingers and the thumb in opposition and flexed over the fingers. Variation range between hands is usually within 10%.Grip and pinch dynanomometer have both yielded similar reproducible and consistent results.

KEY PINCH MEASUREMENT

The key pinch position is achieved by opposing the radial surface of the middle phalanx of the index against the pulp of the thumb. The pressure on the thumb is increased by stacking up the remaining fingers behind the index finger by exerting the interossei.

The modified sphygmomanometer is used to measure Key pinch from both the normal and reconstructed hand. The mean and percentage is calculated after comparing with the normal hand.

TRIPOD PINCH MEASUREMENT

The digital pulp of the thumb is made to touch the pulps of middle and index fingers. This arrangement of the index finger in pronation and middle in supination along with the thumb resembles the power drill instrument's chuck.

Measurement of the Tripod pinch is done by a simply modified Sphygmomanometer.This is constructed by assembly of a rubber bulb, sphygmomanometer and a silicone tube. Using this modified instrument, tripod pinch can be measured from both hands- the normal and the reconstructed. From these measurements, mean and percentage are calculated and compared with the normal hand.

SENSORY ASSESSMENT

Two point discrimination test was done over the reconstructed contact surface of the thumb, using a two point discriminator (calibrated calipers)

The values for two point discrimination in the normal hand vary in different areas. Initially the calipers is set at 15mm and then brought together gradually.

A comparison test is first done in the normal hand. The rules that should be strictly maintained are:

1. There should be an interval of 3-4 seconds between each test
2. Application must be performed gently, without causing the blanching of skin at each point
3. Simultaneous contact of the two points must be obtained in the line of the digit

4. Testing must be done starting distally at the fingertip and proceeding proximally only after checking all the fingertips.

5. Standardization of marking is done by Omer system for all tests.

Omer's system selects two correct values of three assessments .Moving two point discrimination must be done prior to static two point discrimination.

NORMAL TWO POINT DISCRIMINATION

Tip of Thumb - 3 to 4 mm

Distal phalanx of finger - 3 to 5 mm

Middle phalanx of finger - 3 to 6 mm

Proximal phalanx of finger - 4 to 7 mm

MICHIGAN HAND OUTCOMES QUESTIONNAIRE (MHQ)[43]

The Michigan Hand Outcomes Questionnaire is an established system used for the complete assessment of functional and aesthetic result following completion of reconstruction

It is composed of 11 components and scored accordingly

1. Pain(1 for both)
2. Activities of Daily Living (ADL)- (1 point each for left and right hands and 1 for both)
3. Work(1 for both)
4. Overall Function of the Hand (1 point each for left and right hands)
5. Aesthetic (1 point each for left and right hands)
6. Satisfaction (1 point each for left and right hands)

The response and validation of the MHQ score has been proved for a variety of hand conditions. The MHQ scoring system provides the plastic surgeon the advantage of using a single common system for assessing research outcomes related to the hand. The broad applications include the comparison of outcomes across different pathologies of the hand with relation to results in the hand before and after reconstruction.

OVERALL FUNCTION OF HAND (WORDED FOR RIGHT OR LEFT)

The overall function of the hand is assessed by the following questionnaire for the previous week

1. On the whole, how well do you think your hand worked?
2. How would you say your fingers moved?
3. How would you say your wrist moved?
4. What would you say about the strength of your hand?
5. What would you say about the feeling (sensation) in your hand?

Points	Response

Very Good	1
Good	2
Fair	3
Poor	4
Very Poor	5

ACTIVITIES OF DAILY LIVING FOR RECONSTRUCTED HAND

The assessment of ADL (Activities of Daily Living) for the reconstructed hand with reference to the ability of the person to perform assigned tasks for the past week:

How much difficulty did you have while doing the following things with your hand for the past week?

1. Picking up a coin

2. Holding a glass of water

3. Holding a frying pan

4. Turning a key in the lock

5. Turning a door knob

Points	Response
1	No difficulty at all
2	A little difficulty
3	Somewhat difficult
4	Moderate difficult
5	Very difficult

ACTIVITIES OF DAILY LIVING USING BOTH HANDS

Assessment of function for the past week

How much difficulty did you have while performing the following activity during this past week while using both hands?

1. Eating with a knife, fork or spoon
2. Buttoning a shirt or a blouse
3. Carrying a grocery bag
4. Opening a jar
5. Washing dishes
6. Washing your hair
7. Tying knots and shoelaces

Points	**Response**
1	No difficulty at all
2	A little difficulty

3	Somewhat difficult
4	Moderate difficult
5	Very difficult

NORMAL WORK

The questionnaire refers to the normal work that you did in the past four weeks

1. How frequently did you find yourself unable to work because of trouble with your hand?
2. How frequently did you have to cut short your working day because of trouble with your hand?
3. How frequently did you have to take a break from work because of trouble with your hand?
4. How frequently did you achieve less at work due to trouble with your hand?
5. How frequently did you take a longer time to perform your work due to trouble relating to your hand?

Points	Response
1	Always
2	Often
3	Sometimes
4	Rare
5	Never

PAIN

The given questionnaire refers to how much pain you would attribute to your hand in the past week

1. How frequently did you experience pain in your hand?

2. How would you describe the pain that you have in your hand?

3. How frequently did you have difficulty sleeping due to pain in your hand?

4. How frequently in the pain in the hand obstruct daily activity?

5. How frequently were you upset due to pain in your han

Response for Question 1, 3, 4 and 5	**Points**
Always	1
Often	2
Sometimes	3
Rarely	4
Never	5
Response for 2	**Points**
Very mild	5
Mild	4
Moderate	3

Severe	2
Very Severe	1

APPEARANCE

The below questionnaire refers to the appearance of your hand for the previous week

1. The appearance of my hand was acceptable
2. I found that I was sometimes uncomfortable in public due to the appearance of my hand
3. I was depressed due to the appearance of my hand
4. The appearance of my hand was a hindrance in my social activity

Response	**Points for 1**	**Points for 2,3,4**
Strongly agree	5	1
Agree	4	2
Neither agree nor disagree	3	3

Disagree	2	4
Strongly disagree	1	5

SATISFACTION

The questionnaire below refers the level of satisfaction you attribute to your hand in the past one week

1. Pain in

Response	Points

your hand
2. Movement of fingers in your hand
3. Movement of your wrist
4. Overall Function of your hand
5. Strength of your hand
6. Sensation in your hand

Very satisfied	1
Somewhat satisfied	2
Neither satisfied nor dissatisfied	3
Somewhat satisfied	4
Very dissatisfied	5

Raw score for pain = SUM (points for pain in each hand)

Raw score for activities of daily living = SUM (Points for function in each hand)

Raw score for work = SUM (Points for work in each hand)

Raw score for aesthetics= SUM (points for aesthetics in each hand)

Raw score for satisfaction = SUM (Points for satisfaction in each hand)

Raw score for overall hand function = SUM (Points for function in each hand)

INTERPRETATION

Score range for Activities of Daily Living : 5 to 25 for 1 hand, 5 to 35 for both hands

Score range for work: 5 to 25

Score range for aesthetics: 4 to 20

Score range for satisfaction: 6 to 30

Score range for Overall Hand Function: 5 to 25

Missing values may affect the validation of the score. If more than 50% of the items are unanswered then that particular subscale cannot be graded.

If 1 or 2 items are missing then the average of the known items can be used to infer the missing data.

Normalization of the raw scores in the range 0 to 100% (100% is normal)

Activity of daily living in percent with 1 hand =

[(25-Raw score)/20] X100%

Activity of daily living in percent with 2 hands= [(35- Raw score)/28] X100%

Overall hand function in percentage =[(25-Raw score)/20] X 100 %

Overall ADL = (ADL for hand) + (ADL for 2 hands) /2

If there is no pain in the hand ("never response to the first question) the pain score is 5 and function is 100%.

If there is any pain in the hand (not "never" response to the first question) then the pain in percent [(25-raw score)/20] X100%

Aesthetic in percent = [(Raw score -4)/16]X100%

Satisfaction in percent = [(30- Raw score)/24]X 100%

PERFORMANCE

Reliable instrument was used and valid for measuring the outcomes.

Cronbach's alpha ranges from 0.86 to 0.97

Spearman's Correlation Test-Retest reliability ranged from 0.81 to 0.97

Correlation between scales indicted construct validity.

RESULTS

Our study results are

Patient underwent Single stage thumb reconstruction are consider as “GROUP A” where as patient underwent staged osteoplastic reconstruction are consider as “GROUP B”.

In Group A –youngest age at reconstruction was 14 years and the oldest was 40 years. The average age at reconstruction was 26 years, where as in Group B- youngest age at reconstruction was 16 years and the oldest was 45 years. The average age at reconstruction was 28 years.

In both group male and female, underwent reconstruction were in the ratio of 4: 1.

In both group right side was commonly affected than left side.

In both the group industrial accident was found to be the commonest cause of thumb loss. Other etiologies were Road Traffic Accident and assault.

Group A average two point discrimination in the reconstructed thumb was 8mm and group B two point discrimination was 9mm.

Group A average Kapandji’s opposition score was 7 and group B average kapandji’s opposition score was 6.

In Group A none of the patient was developed thumb web contracture whereas in group B, 4 patients developed thumb web contracture.

Group A patient average grip strength of the reconstructed thumb was 44 % where as in group B average grip strength of the reconstructed thumb was 39 %.

Group A average tripod pinch strength recorded was 45 % whereas Group B average tripod pinch strength recorded was 40 %.

Group A average key pinch strength recorded was 50 % whereas Group B average key pinch strength recorded was 46 %.

Group A patient activity of daily living (ADL) using both hands-80 % whereas Group B patient activity of daily living (ADL) using both hands-78 % Group A patient activity of daily living (ADL) using reconstructed hand-73 % whereas Group B patient activity of daily living (ADL) using reconstruction hand-71 %.

Group A reconstructed thumb pain score was-12 % whereas Group B reconstructed thumb pain score was-13 %.

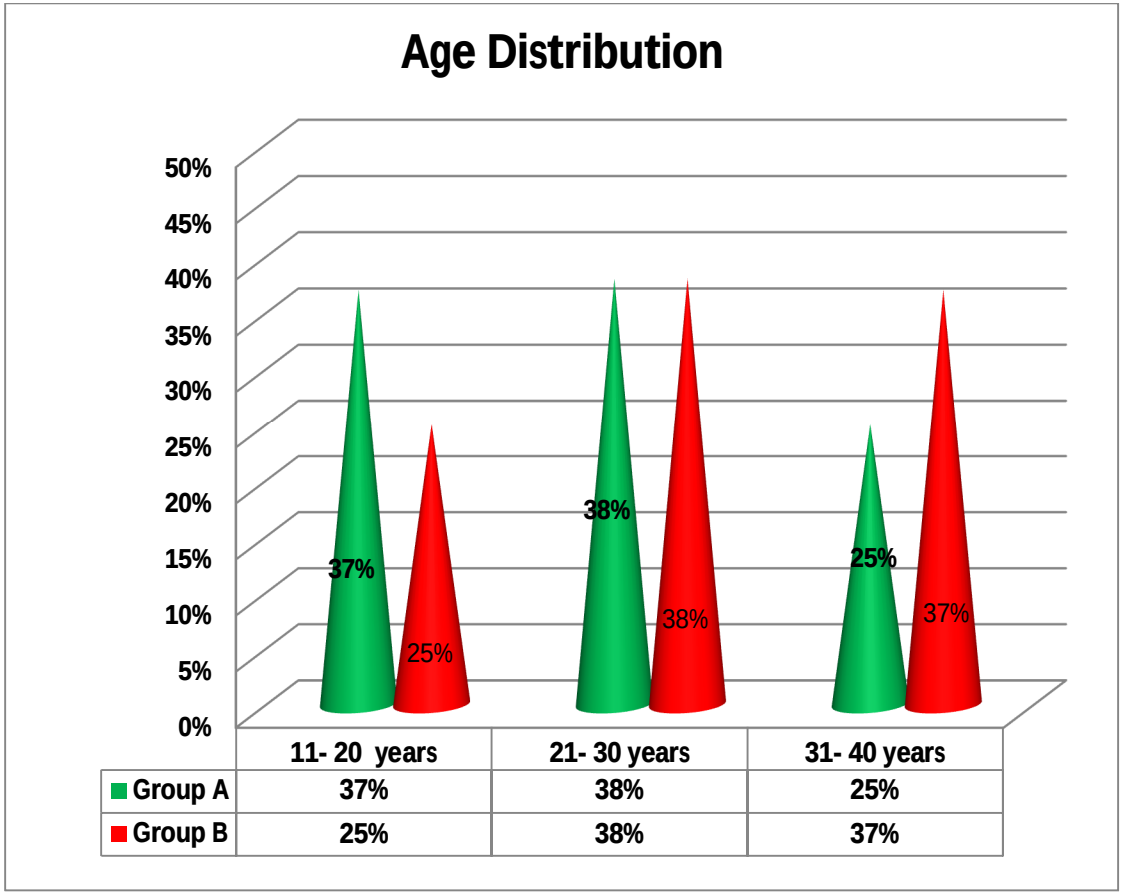
Group A reconstructed thumb aesthetic score was-81 % whereas Group B reconstructed thumb aesthetic score was-74 %.

Group A reconstructed thumb satisfaction score was-85 % whereas

Group B reconstructed thumb satisfaction score was-76 %.

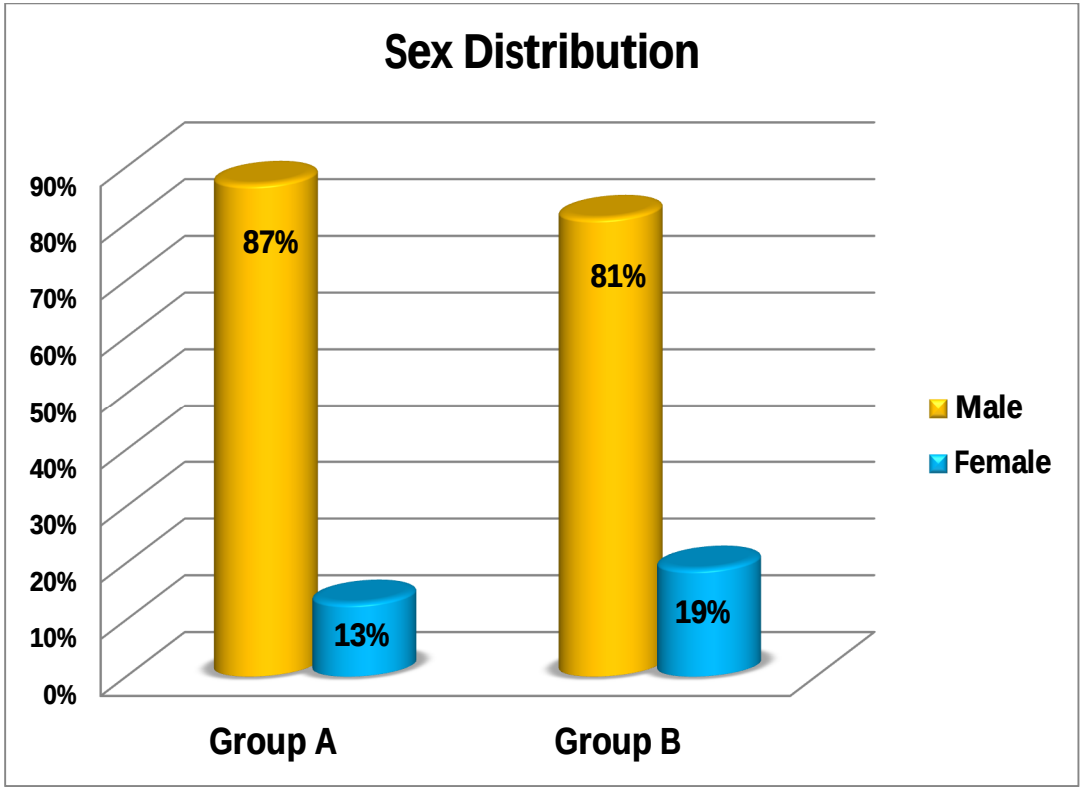
DISCUSSION

In our study, most of the patients who underwent thumb reconstruction in both the groups' belonged to younger age group. The average age in group A was 26 years and in group B was 28 years. Age is a major limiting factor for any procedure that relies on neurotisation at the recipient site to re-establish sensibility in the reconstructed thumb. Younger patients have good recovery of sensation than patients aged more than 35 years. In our study, neurovascular island flap was used for restoration of sensation.

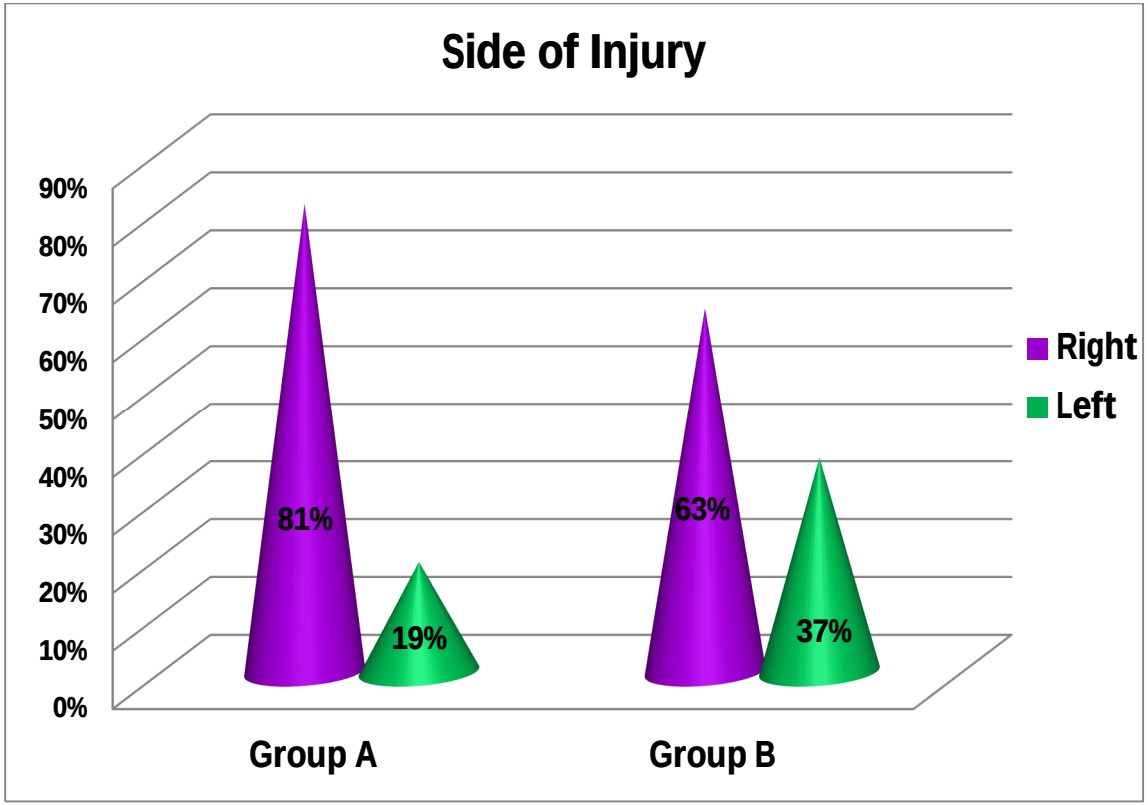

Age Distribution
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
37%
25%
38%
38%
25%
37%
11- 20 years
21- 30 years
31- 40 years
Group A
37%
38%
25%
Group B
25%
38%
37%

Number of males who were reconstructed in group A was 14, as against 2 females. In group B it was 13 males as against 3 females.

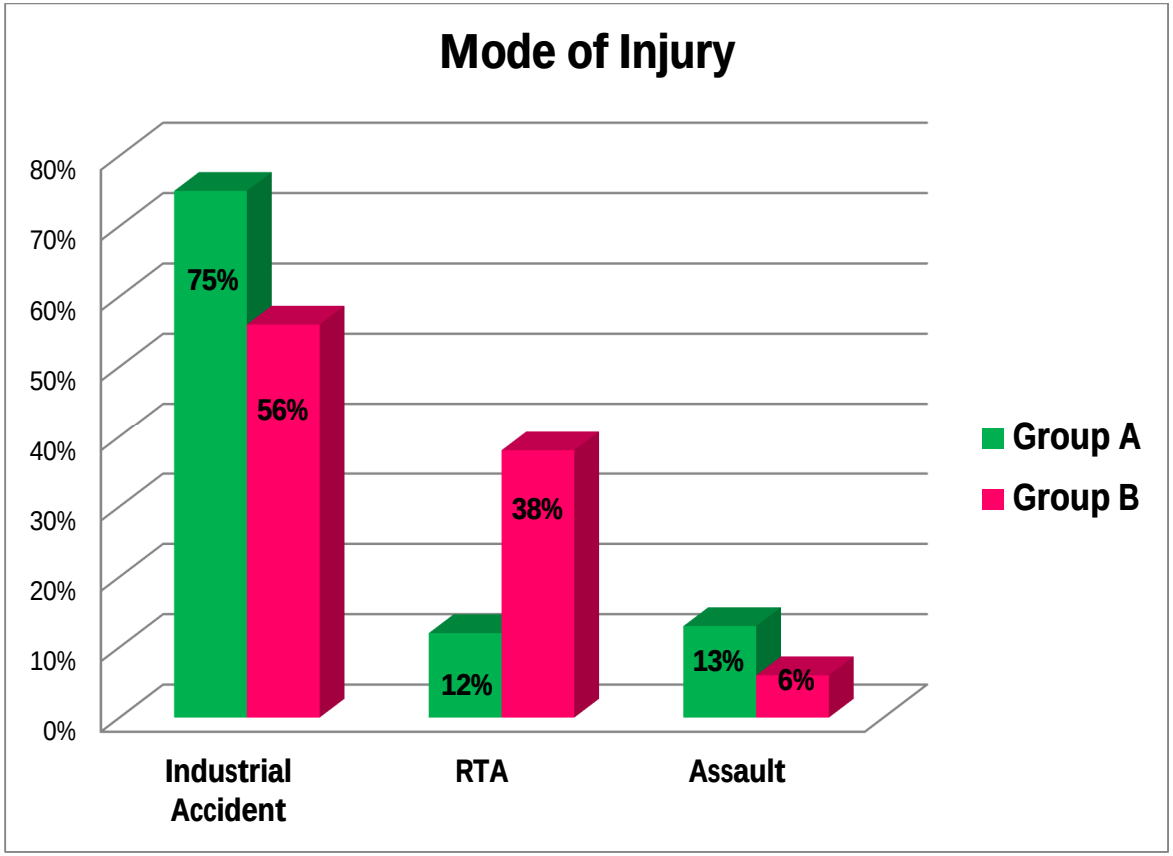
Hence in our population, males were involved more commonly in industrial accidents.


Sex Distribution
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
87%
13%
81%
19%
Group A
Group B
Male
Female

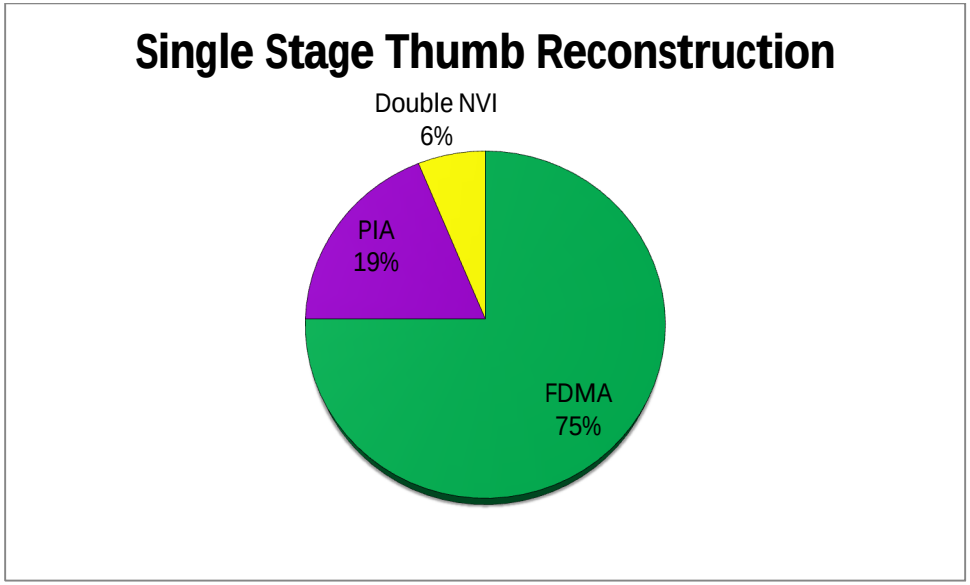
Reconstruction of thumb in the dominant hand influences the functional outcome. In our study, 13 patients in group A and 10 patients in group B had reconstruction done on the right side, whereas 3 patients in group A and 6 patients in group B had reconstruction on the left side.


Side of Injury
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
81%
19%
63%
37%
Group A
Group B
Right
Left

Industrial accidents were found to be the commonest mode of injury in both the study groups, followed by road traffic accidents and assault.


Mode of Injury
80%
70%
60%
50%
40%
30%
20%
10%
0%
75%
56%
12%
38%
13%
6%
Industrial Accident
RTA
Assault
Group A
Group B

In our study , 12 FDMA(First Dorsal Metacarpal Artery), 3 PIA(Posterior Interosseous Artery) and 1 Double NVI (Neuro Vascular Island) flaps were used in single stage thumb reconstruction.


Single Stage Thumb Reconstruction
Double NVI
6%
PIA
19%
FDMA
75%

In our study, average two point discrimination in the reconstructed thumb in group A was 8 mm (range 6-11 mm), and in group B it was 9 mm (range 7-12 mm).

Group A patients who underwent thumb reconstruction by first dorsal metacarpal artery flap, had two point discrimination of 10 mm. Group B patients who underwent thumb reconstruction by groin flap, had poorer sensory recovery than patients who had first dorsal metacarpal artery flap.

In our study, better functional outcome was seen in group A patients than patients who underwent staged reconstruction of the thumb, because early mobilization of CMC joint as early as 3 weeks was possible only in single stage thumb reconstruction.

In both groups of patients, MP joint and IP joint movements were not possible due to bone grafts pegged into metacarpal head. Hence pinch strength and opposition are comparable in both the groups.

In group A, average grip strength achieved was 44% as against 39% in group B. Grip strength depends upon the level of amputation and extent of associated injuries to the hand. Amputations at or distal to the MCP joint were taken up for our study in both the groups. Associated hand injuries were not taken into account. The grip strength achieved was not enough for manual labourers to do heavy manual work but is good enough to do less manual jobs and to carry out activities of daily living.

Average tripod pinch strength achieved in group A was 45%, as against 40% in group B. Tripod pinch strength is influenced by the same factors which determine the grip strength. Patients with good tripod pinch strength perform precision activities better and have managed well with activities of daily living.

Average key pinch strength achieved in our study was 50% in group A and 46% in group B.

Kapandji's opposition score achieved had an average of 7 in group A and 6 in group B. since MP and IP joint movements were static in both our study groups; achievement of higher scores was not possible. Hence the strength of the reconstructed thumb in both the group was significantly reduced during activities at work and of daily living.

The MHQ Michigan Hand Outcomes Questionnaire was used to grade the aesthetic and functional outcomes.

ADL (Activities of Daily Living) scoring for Group A was 80% compared to 78% in Group B.

In both the groups, the patents were able to perform nearly all the daily tasks. There was an increase of 2% in Group A patients indicating that the range of recovery was more in the patients belonging to Group A.

Aestheic scoring attained by Group A was 81%; the average score for Group B was 74%.

Even though the vast majority of patients belonging to Single Stage reconstruction were satisfied with the final outcome of appearance,

The patients who had undergone staged reconstruction were less satisfied.

In both groups, donor site morbidity was evaluated:

Contour deformity of the index finger along with skin graft over the visible portion of the forearm in PIA flap and dorsum of index finger in FDMA flap.

The hidden donor site of the groin flap is comparatively superior to the visible donor site morbidity of single stage reconstruction procedure

CONCLUSION

The thumb contributes approximately 40% of hand function. Hence loss of thumb is considered a major disability. Several techniques areavailable to reconstruct the thumb following trauma and the method of reconstruction is based on the patient choice and surgical experience.

Single stage thumb reconstruction using FDMA flap and N-V island flap, PIA flap and N-V island flap is simple, safe and versatile, particularly where microsurgical techniques are not available. This method of reconstruction replaces “LIKE FOR LIKE” tissue.

In our study, we found that Single stage reconstruction using FDMA flap and N-V island flap (neurosensory flaps) are considered as the ideal method of reconstruction. Single stage reconstruction allows early mobilization of CMC joint and produces better functional outcome when compared to staged osteoplastic reconstruction.

In our study, patients that underwent single stage thumb reconstruction with “LIKE TISSUE” replacement recovered with better grip strength and key pinch (both required for activites of daily living and work, specially in manual labourers) than patients who had staged thumb reconstruction.

Single stage reconstruction fulfils all the criteria for an ideal reconstruction of thumb like stability, length, mobility, sensibility than staged reconstruction, especially FMDA flap in single stage reconstruction retains better sensation than groin flap in staged reconstruction.

Single stage ‘LIKE TISSUE “ thumb reconstruction patient had better aesthetic appearance than staged reconstruction using groin.

Single stage reconstruction patients had high satisfaction regarding the appearance and the overall functional outcome of hand than staged reconstruction.

The disadvantages common to both groups were due to the primary injury (loss of Nail-Nail bed complex and IP Joint).

Patients are less satisfied with the aesthetic outcome in PIA flap forearm donor site (secondary defect) .

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PROFORMA

Name: Age /Sex:

PS No: Cell no:

Address:

Date of injury: Date of Surgery:

Nature of injury: Other injuries:

Smoking: Diabetes mellitus:

Surgical procedure done: Side / Handedness:

Time elapsed since injury: ------ months

Time elapsed since surgery: ------ months

Regularity of patient for physiotherapy: Regular / Irregular

FUNCTIONAL ASSESSMENT

Range of CMC joint movements (Active) – in degrees

Flexion

Extension

Adduction

Palmar abduction

Radial abduction

Range of CMC joint movements (Passive) – in degrees

Flexion

Extension

Adduction

Palmar abduction

Radial abduction

Opposition (Kapandjis Grade)

Grip strength (in percentage, comparison to opposite / normal side)

Key pinch strength (in percentage , comparison to opposite / normal Side)

Tripod pinch strength (in percentage, comparison to opposite / normal Side)

Sensation (2 point discrimination) –

Thumb web contracture – present / absent

Willingness for toe transfer if offered as choice – Willing / not willing

Work situation since reconstruction – same / downgraded / not working

MASTER CHART

S No	Name	Age(years)	Sex	Side	Mode	2PD	Kapandjis	TWC	Grip Str	Tripod	Key pinch	ADL – both	ADL - recon	Pain	Aesthetic	Satisfaction
1	Easwari	38	Female	Right	Ind.Acci	6mm	8	Pos	50%	52%	60%	93%	85%	10%	78%	80%
2	Karthik	14	Male	Right	Ind.Acci	6mm	7	Pos	48%	46%	50%	82%	74%	10%	78%	84%
3	Kumar	25	Male	Right	Assault	7mm	7	Neg	38%	32%	38%	69%	60%	5%	88%	94%
4	Manikandan	22	Male	Right	Ind.Acci	6mm	7	Pos	45%	43%	48%	78%	70%	15%	78%	82%
5	Murugan	30	Male	Right	Ind.Acci	6mm	8	Neg	43%	37%	42%	76%	68%	15%	76%	77%
6	Rajesh	28	Male	Right	Ind.Acci	7mm	6	Pos	38%	52%	35%	62%	54%	15%	76%	80%
7	Ramesh	20	Male	Left	Ind.Acci	7mm	7	Neg	56%	54%	60%	91%	86%	10%	80%	88%
8	Rajan	23	male	Right	Ind.Acci	8mm	8	Neg	56%	50%	60%	92%	86%	10%	88%	90%
9	Santhosh	18	Male	Right	Ind.Acci	7mm	8	Neg	39%	37%	42%	76%	68%	10%	86%	90%
10	Saranya	20	Female	Right	Ind.Acci	8mm	6	Neg	38%	38%	66%	64%	54%	20%	74%	80%
11	Shantakumar	26	Male	Right	Ind.Acci	9mm	8	Neg	36%	36%	40%	72%	68%	5%	84%	88%
12	Srinivasan	36	Male	Right	RTA	7mm	8	Neg	56%	58%	62%	90%	82%	15%	84%	86%
13	Sukumar	40	Male	Right	Ind.Acci	11mm	7	Neg	42%	48%	54%	88%	79%	15%	72%	76%
14	Sundar	18	Male	Left	RTA	8mm	8	Neg	39%	47%	42%	78%	69%	20%	82%	88%
15	Suresh	40	Male	Right	Ind.Acci	9mm	7	Neg	36%	40%	54%	88%	80%	15%	80%	84%
16	Thananchezhian	20	Male	Left	Assault	8mm	7	Neg	41%	43%	50%	84%	78%	5%	90%	92%
	Average	*26.125*				7.5mm	*7.3125*		*44%*	*45%*	*50%*	*80%*	*73%*	*12%*	*81%*	*85%*

S no	Name	Age	Sex	Side	Mode	2PD	Kapandjis	TWC	Grip Str	Tripod	Key pinch	ADL – both	ADL - recon	Pain	Aesthetic	Satisfaction
1	Arumugam	36	Male	Right	RTA	8mm	7	Neg	34%	38%	52%	86%	78%	15%	75%	77%
2	Balu	22	Male	Right	Assault	7mm	6	Pos	46%	44%	48%	80%	72%	5%	72%	74%
3	Ganesan	20	Male	Right	Ind.Acci	8mm	7	Neg	44%	48%	58%	90%	84%	10%	85%	87%
4	Kaniappan	32	Male	Left	Ind.Acci	8mm	6	Neg	37%	35%	40%	74%	66%	10%	80%	82%
5	Karan	18	Male	Left	RTA	9mm	7	Neg	54%	52%	58%	89%	84%	10%	72%	70%
6	Kasinathan	23	Male	Left	Ind.Acci	8mm	6	Pos	38%	50%	58%	91%	83%	15%	70%	72%
7	Kumudha	28	Female	Left	Ind.Acci	7mm	6	Pos	28%	30%	33%	60%	52%	20%	70%	73%
8	Paneer	30	Male	Right	Ind.Acci	8mm	5	Neg	41%	35%	40%	74%	66%	10%	70%	68%
9	Pitchaimuthu	42	Male	Right	Ind.Acci	7mm	6	Pos	43%	41%	46%	76%	68%	15%	68%	66%
10	Rajkumar	17	Male	Right	RTA	10mm	7	Pos	39%	41%	48%	82%	76%	5%	82%	85%
11	Ravi	16	Male	Left	RTA	12mm	6	Neg	37%	35%	40%	76%	67%	20%	76%	78%
12	Sakthivel	25	Male	Right	Ind.Acci	9mm	7	Neg	32%	30%	36%	67%	58%	10%	82%	80%
13	Sivamani	43	Male	Right	Ind.Acci	7mm	7	Neg	32%	34%	38%	70%	66%	10%	78%	80%
14	Usha	40	Female	Right	Ind.Acci	10mm	5	Neg	54%	56%	60%	88%	80%	20%	74%	77%
15	Vanidasan	27	Male	Right	RTA	7mm	7	Pos	26%	28%	34%	62%	52%	20%	68%	70%
16	Vanitha	34	Female	Left	RTA	8mm	8	Neg	40%	46%	52%	86%	77%	20%	68%	71%
	Average	*28.3125*				*8.4mm*	*6.4375*		*39%*	*40%*	*46%*	*78%*	*71%*	*13%*	*74%*	*76%*

INTRODUCTION

The presence of an opposable thumb has provided man with unique functional capability. [1] Daily tasks involving pinch, grasp, grip and precision handling are more easily accomplished with an opposable thumb. Congenital absence or hypoplasia, traumatic [1] loss diminishes or eliminates the thumbs prehensile abilities and may affect overall hand function.

The [14] loss of the thumb alters the aesthetic symmetry of the hand and can result in up to 40% impairment of hand function. Hence significant interest has been developed all over the world, during the years in the development of various methods of thumb reconstruction.

Various methods have evolved over the years; the following methods have emerged as the preferred ones:

1. Osteoplastic reconstruction of thumb using skin cover, bone graft and a