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Original Article

Results of Dynamic Claw Correction in Ulnar nerve Palsy

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Abstract:

Normal hand function is a balance between the extrinsic-intrinsic and extensor-flexor group of musculature. Although individually the intrinsics are very small muscles, collectively they contribute about 50% of grip strength. Total 19 patents with claw deformity were corrected by 4 different techniques. 11 claws were due to high ulnar nerve palsy and 8 were due to low palsy. Result was excellent in 9 (47.36%), good in 7(36.84%), fair in 2(10.52%) and poor in 1(05.26%) patient. Zancolli's Lasso was the most common procedure used for correction of claw deformity. 1(05.26%) patient developed swan neck deformity treated by FDS 4 tail procedure of low lesion group and final result was fair, another 1 (05.26%) patient developed contracture of the PIP joint. Though exact biomechanical correction of claw is complicated yet function of the hand can be improved with different techniques of tendon transfer.

Key words: *Dynamic claw correction, Ulnar nerve palsy.*

Introduction:

Most activities of the hand require two basic positions i) grasp ii) pinch. Normally to grasp a large object the metacarpophalangeal (MCP) joints flex first until the proximal pulp touches the object and it is done by the intrinsic muscles of the hand. Then the PIP and DIP joints flex respectively to secure the object firmly[1]. This is powered by flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) respectively. In claw deformity the synchronous flexion of the MCP and IP joints are lost. The MCP joint flexion occurs only after the full flexion of the DIP and PIP joints. As a result the item to be hold is pushed out of the grip before they are secured in the palms. The speed & performance of hand improves if MCP is supported in lumbrical position & this is the basis of claw correction. Interossei are primary flexor of the MCP joints & all are innervated by the ulnar nerve. Individually the intrinsics are small muscles but collectively they contribute more than 50% of grip strength[2]. So as a whole there is 50% loss of grip strength in ulnar nerve palsies. Also synergism and fine coordination of finger movement is lost which is necessary for all delicate activities of the hand [Figure-1].

Fig.-1: *Long standing claw hand deformity affecting all fingers.*

Mechanism of clawing: Intrinsic muscles arise from the flexor surface of the hand, pass volar to the MCP joint and inserted to the extensor mechanism at the back of fingers. Their primary functions are flexion of MCP joint and extension of the interphalangeal (IP) joints. It also acts as checkrein to prevent hyperextension of the MCP joint. Saggital bands arise from lateral edge of extensor hood, sweep volarly to insert in the volar plate distal to the MCP[2]. When extensor digitorum communis (EDC) contracts, the

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Table-I

Distribution of Patient, procedure, Result and complications.

Procedure	No. of Pt	Mean Age (Y)	Mean time of paralysis (M)	Level of injury	Results	Complications	Mean follow up period (M)
ZLP	9	23	26	high-6	High- Excellent-4, Good-2		
				Low-3	Low- Excellent-1, Good-2		10
FDS 4-tail	5	34	29	High-2	High-Excellent-1, Good-1	Swan neck deformity-1	12
				Low-3	Low- Excellent-1, Good-1, Fair-1		
ECRL 4-tail	3	38	31	high-2	High- excellent-1, Good-1	PIP contracture-1	11
				Low-1	Low- Poor-1		
PL 4-tail	2	21	18	High-1	High-Excellent-1		9
				low-1	Low-Fair-1		

MCP joint is hyperextended secondary to tension on volar plate, which is normally opposed by intrinsics [3]. The EDC become slack due to hyperextension of the MCP; so the tension of the dorsal hood distal to the MCP joint is inadequate and fails to complete excursion over PIP & DIP joint to allow extension and the IP joints do not open up. Simultaneously long flexors unopposedly pull DIP and PIP to keep them flexed[2]. All these produces claw deformity.

Patients and Methods:

Between May 2006 and September 2011, 19 patients with ulnar nerve palsy underwent claw corrective surgery. In 12 patients the clawing was due to neglected leprosy and in 7 patients due to trauma. High ulnar nerve palsy was in 11 and low palsy was in 8 patients. The average age of the patients was 28 years, ranging from 17 to 55 years. There was preoperative extensor lag of PIP joint in 8 patients. Less than 30^0 extensor lag was in 5 patients and more than 30^0 in 3 patients. 9 patients were reconstructed with Zancolli's Lasso Procedure (ZLP) 5 patients with the Flexor digititorum superficialis 4-tail (FDS 4-tail), 3 patients with the Extensor carpi radialis longus 4-tail (ECRL 4-tail) and 2 patients with palmaris longus 4-tail (PL 4-tail) procedure. The mean age, follow-up, and paralysis times are summarized in Table 1. The mean paralysis time was 25 (range 18-32) months. The period of postoperative follow-up evaluation varied from 6 to 16 months with the average being 13 months.

Surgical Technique: The basic procedure of the claw correction is to replace the function of the lumbrical and interossei muscles means flexion of MCP joint before IP joint flexion. They can be done by several techniques.

The FDS Lasso transfer to A_1 pulley (Zancolli's Lasso Procedure)[4,5]: is indicated in supple hand without hypermobility of the PIP joint (no assisted angles). It is not indicated if there is i) presence of assisted angle present (leads to residual PIP flexion after surgery) ii) hypermobile PIP joint of donor digit (likely to result in an intrinsic plus deformity) iii) weakness of profundus/sublimis of donor digit (may compromise flexion and inadequate result is inevitable).

To perform the Lasso procedure; A_1 pulleys of medial 4 fingers were exposed by a transverse incision over distal palmar crease extending from radial to ulnar border [Figure-2]. The FDS tendon of the ring or middle finger was transected near its insertion to the middle phalanx through the same wound

Figure-2: *Harvesting FDS of ring finger for transfer.*

and was withdrawn into the palm [Figure-3]. The tendon was split longitudinally into 4 equal tails one for each finger [Figure-3]. Each slip was then looped around the A1 pulley, and sutured on itself at the MCP joint level. Proper tension was adjusted with the wrist in 45° dorsiflexion, the MCP joints at 70° flexion, and the IP joints in complete extension. Peroperative adjustment of the tension was tested with the fingers are near full extension when wrist is flexed and near

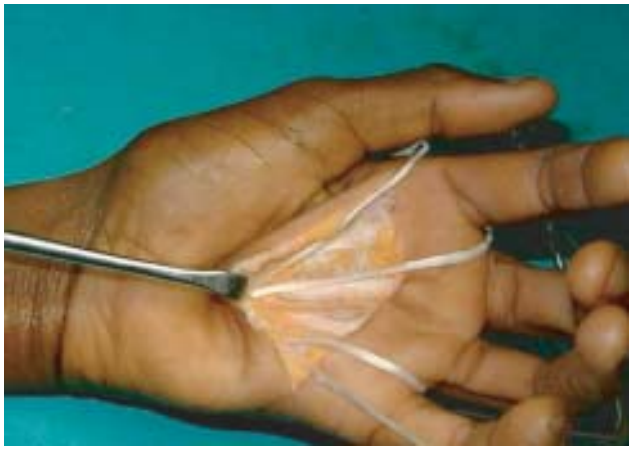

Figure-3: *FDS is divided in 4 slips for each finger. The A_1 pulleys are also exposed.*

full flexion when the wrist is extended along with maintenance of good hand cascade [Figure-4,5]. After

Figure-4: *Tension adjustment, Fingers are flexed with wrist in extension. Good hand cascade is maintained.*

Figure-5: *Extended fingers with wrist in flexion.*

wound closure this position was maintained for 4 weeks in a plaster splint.

The FDS 4-tail to lateral band procedure (Modified Stiles-Bunnell Transfer): The procedure is indicated for relatively stiff hand where more power is required to flex the MCP joints as after release of contracture with physiotherapy called non pliable hand. The procedure is not suitable where the long finger flexors (FDS/FDP) of donor digit are weak or the PIP of donor digit is hypermobile. For the Stiles-Bunnell transfer[6,7] the radial slip of the FDS tendon of middle finger was transected near its insertion and withdrawn through the incision in the palm. The tendon was split longitudinally into 4 equal tails. Each slip was passed through the lumbrical canal of each finger and attached to the radial lateral bands of the middle, ring, and small fingers, and the ulnar lateral band of the index finger with proper tension adjustment.

The Extensor carpi radialis longus (ECRL) 4-tail transfer to lateral band procedure (Brand's intrinsic transfer)[4]: The procedure is indicated for the stiff hand where more power is required to flex the joints as after release of contracture with physiotherapy called non pliable hand. The procedure is suitable where the long finger flexors (FDS and FDP) of donor digit are weak as in high ulnar nerve palsy. It is also applicable in hypermobile PIP joint of donor digit.

The ECRL tendon was divided at the insertion and withdrawn through a second incision 5 to 6 cm proximal to the wrist. The length of the motor unit was inadequate to reach the finger and need a graft. The palmaris longus (PL) tendon was harvested and sutured to ECRL to increase length to reach finger. The motor-graft unit was passed to the palm through subcutaneous space and splitted to 4 slips. The slips were passed volar to the deep transverse metacarpal ligament (fulcrum for MCP joint flexion) and attached like modified Stiles-Bunnell Transfer.

The Palmaris Longus (PL) 4-tail procedure: Is indicated in a patient having supple hand with hypermobility of PIP joints & Weakness of FDS and or FDP. The palmaris longus muscle was used for the motor power and either plantaris or fascia lata was used as graft to increase length to reach the fingers. The rest of the procedure was similar to the Brand intrinsic transfer.

Table-II

Description of functional assessment methods modified from Brand's evaluation criteria[4]

Grading	Open Hand Assessment	Closed Fist Analysis	Mechanism of Closing
Excellent	No residual flexion contracture at the PIP Jt	Fully tight fist	Can complete the MCP flexion before the IP joints begin to flex
Good	$0\text{-}30^0$ extension lag of the PIP jt, no flexion at the DIP jt	Finger closes fully, but not tight enough to hold a hypodermic needle	IP jt flexion begins just before MCP flexion is complete
Fair	$31\text{-}60^0$ extension lag of the PIP jt, slight flexion at the DIP jt	A visible gap between base of the finger and the tip	IP jt begins and continues along with MCP flexion
Poor	$>60^0$ extension lag of the PIP jt	One finger breadth gap between base of the finger and the tip	MCP flexion delayed behind IP flexion

PIP (Proximal interphalangeal joint), DIP (Distal interphalangeal), MCP (Metacarpophalangeal), IP (Interphalangeal).

Figure-6: *Post operative correction of claw by Zancolli-Lasso method. Full flexion of MCP and IP joints.*

Results:

Results were evaluated by modified Brand's evaluation criteria (Table-II). Result was excellent in 9 (47.36%), good in 7(36.84%), fair in 2(10.52%) and poor in 1(05.26%) patient. Of the 9 excellent results

7(36.84%) clawing was due to high lesion and 2 (10.52%) due to low lesion. 9 (47.36%) patients were treated by ZLP [Figure-6, 7]. 4 (21%) patients had excellent and 2 (10.52%) patients had good result of the 6 high lesion

group patient treated by ZLP. On the other hand 1 (05.26%) patient had excellent and 2 (10.52%) patients had good result in rest of 3 (15.78%) low lesion group patients treated by ZLP. Among 5 (26%) patients of FDS 4 tail group patients, 2 (10.52%) had high lesion. 1 (05.26%) patient had excellent and 1 (05.26%) patient had good result. Rest 3 patients of low lesion group FDS 4 tail procedure showed excellent result in 1 (05.26%), good in 1 (05.26%) patient and fair in 1 (05.26%) patient. 3 (15.78%) patients were treated by ECRL 4 tail procedure. 1 (05.26%) patient had excellent and 1 (05.26%) patient had good result of high lesion group treated by ECRL 4 tail procedure. 1 (05.26%) poor result was found in low lesion group of ECRL 4 tail procedure. 1 (05.26%) patient had excellent result of high lesion group treated by PL 4 tail procedure and 1(05.26%) patient of low lesion group showed fair results that had low lesion. There were 2 (10.52%) complications: 1(05.26%) patient developed swan neck deformity treated by FDS 4 tail procedure of low lesion group

Figure-7: *Post operative correction of claw by Zancolli-Lasso method. Full extension of MCP and IP joints.*

and final result was fair, another 1 (05.26%) patient developed contracture of the PIP joint treated by ECRL 4 tail procedure that had also low lesion.

Discussion:

Claw deformity can be corrected either by static or dynamic methods. Static procedure provide static block to prevent MCP joint hyperextension and keep it permanently flexed. So the saggital band moves distally and the extensors get enough excursions over the MCP to extend the PIP and DIP joints. The disadvantage of the procedure that it does not provide active joint flexion and normal synergistic closure of the hand is not restored[8]. The advantage of static procedure is that some mechanics and appearances are restored without much re-education. Some complications of the dynamic procedure such as swan neck deformity and intrinsic plus deformity can also be avoided.

There are several dynamic methods of tendon transfer for claw correction using different functioning tendon. Tendon transfer provides dynamic correction of clawing, integrate MCP and IP flexion, and in some cases augment grip strength. These can be divided into finger motor group using FDS transfers and transfers powered by wrist motors. The standard donor tendons for claw deformity correction are usually the flexor digitorum sublimis (FDS), the extensor carpi radialis longus (ECRL) or the palmaris longus. The site of attachment of the transferred tendon is also different. It can be attached to the proximal annular pulleys of the flexor sheath, the lateral band of the dorsal extensor expansion, the proximal phalanx and the interosseous tendons.

The FDS can be inserted either in the lateral band of extensor apparatus or in the A_1 pulley. The drawback of modified Stiles-Bunnell procedure is PIP joint hyperextension particularly in patients with lax joints[6]. This is because the superficialis tendon, the main flexor of the PIP joint is removed; simultaneously removed power is added to the extensor apparatus. Burkhalter recommended inserting the tendon on the proximal phalanx instead of the lateral band, which can prevent PIP joint hyperextension[9]. Zancolli with Lasso insertion improves MCP joint flexion and simultaneously avoiding PIP hyperextension[5,10]. The splitted 4 slips of donor FDS tendon (for 4 digits correction) have ample length for a lasso procedure and a Pulvertaft weave for a strong insertion[11]. No patient in this series developed PIP hyperextension. ZLP shows 47.36% excellent to good results among all the procedures. The main advantage of superficialis transfers is that it is easy to perform, they reliably correct the clawing and integrate finger flexion; the grip strength is also improved.

An insertion into the lateral band may be preferred if Bouvier's test is negative (complex claw having stiffness of IP joints), but it should be remembered that PIP joint hyperextension may occur[12] Brand, Riordan, and others described the use of wrist-level motors to treat clawing and integrate finger flexion as well as augment grip strength[4,9,10,13]. The Flexor carpi radialis, Extensor carpi radialis longus, Extensor carpi radialis brevis or brachioradialis may be used. These motor units require a free tendon graft to increase the length to reach the fingers. It should be noted that adhesions may develop if the tendons are passed through the intermetacarpal space and the excursion of these transfers will be severely limited. It also prolongs the duration of operation and rehabilitation. It is important to make the opening large enough that the tendon graft can easily pass through this area. The tendon can be inserted into the lateral band, the proximal phalanx, or the A1 or A2 pulley. The main advantage of these tendon transfer procedures over the superficialis transfers is that they improve rather than worsen grip strength. In addition, there is no great loss of function at the level of the wrist. Also, because the superficialis tendon is preserved, the transfer can be inserted on the lateral band with less chance of developing PIP joint hyperextension.

Tendon transfers were successful in restoring grip strength after surgery. Use of FDS (either as FDS 4-tail or ZLP) as donor muscle units was more effective than ECRL. Also the FDS 4-tail procedure was the most successful procedure in correcting claw hand deformity[14]. Our study also shows the similar results. Study shows that the traction from the A1 pulley produces greater force of ûexion of the proximal phalanx, followed by lateral band, bony attachment to the proximal phalanx, and interosseous tendon in a descending manner[5,15]. The number of quantitative clinical studies to confirm these findings however is limited. Hastings and Davidson[16] in their retrospective analysis of 34 cases of ulnar palsy suggested that the transfer using the FDS and lateral band attachment resulted in substantial weakness of grasp.

In a study 15 of 44 patients who had long-standing paralysis were not able to extend their PIP joints fully when the MCP joints were held at 90° ûexion[14]. This so-called Bouvier's maneuver assesses the integrity of the extensor apparatus[5]. Persistent lag of full extension in the absence of joint contracture usually is caused by the elongation of the central slip. This type of elongation as commonly seen in long-standing cases makes the claw hand deformity more prominent and seriously interferes with the hand function.

Conclusion:

Optimum intelligence of the patient is mandatory to identify and separate the function of the transferring tendon that might need to work in a reverse direction such as extensor muscle is working as flexor. Tendon transfer is not the absolute solution for the established claw deformity. But the procedure can only ensure the useful use of a useless hand.

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