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Reconstructive Surgery of Ulnar Claw Hand in Leprosy Patients by Lasso Procedure

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Abstract: Leprosy, Hansen's disease caused by mycobacterium leprae, is widely known. Though there has been a substantial achievement in recent years given eliminating the disease, the deformity caused by the disease needs to be managed by reconstructive surgery. The ulnar nerve being superficial, is the most common nerve affected. When affected, the muscles innervated by the nerve begin to weaken, leading to a disparity between the strong extrinsic muscles and the weakened intrinsic muscles and is characterized clinically by metacarpophalangeal joint hyperextension and flexion of the proximal and distal interphalangeal joint. Doing reconstructive surgery on these patients will help them carry out day-to-day activities and reduce social awkwardness. Corrective surgeries like modified Stiles-Bunnell transfer, extensor carpi radialis graft, Zancolli lasso procedure, and palmaris longus tail graft are known to us. Out of all, the Zancolli lasso procedure was chosen for operating on all our cases because all other surgeries need high precision with proper training and proper post-operative physiotherapy. The study aims to evaluate the functional outcome of patients with leprotic ulnar claw hand operated with the Zancolli lasso procedure. Objectives assessed were deformity correction, grip strength, and range of motion. During the last two years, ten patients with ulnar claw hands came to Sree Balaji Medical College and Hospital, Chennai. They were operated on with the Zancolli Lasso procedure with adequate results. The zancolli procedure is easy to do and can be done in small centers, which restores finger flexion and doesn't harm other superficialis tendons, thus preventing swan neck deformity of the fingers.

Keywords: Leprosy, Ulnar Nerve, Reconstructive Surgery and Zancolli Lasso Procedure

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1. INTRODUCTION

Leprosy is a chronic granulomatous disease caused by Mycobacterium leprae affecting the skin and peripheral nervous system. The World Health Organization declared it a major health problem because of its incapacitating deformities.[1] India continues to have a high share of the world's leprosy population.[2] India is running the most extensive leprosy control program (NLEP) in the world.[3]Still as many as 1,14,451 new cases are reported globally according to the World Health Organization's weekly epidemiological report of 2020. Leprosy is noticeable mainly due to its morbidity and the deformity it causes, along with the psychological and emotional turmoil.[4] The bacilli grow inside the peripheral nerves and damage them, causing sensory loss, as well as gross motor activities, affected causing deformities that not only affect the person socio-economically but also a loss of man power[5]. Nerve damage in leprosy is silent neuropathy or may clinically manifest as weakness, atrophy, or contracture.[6] Long nerves of the limbs are the ones that are affected initially and later get thickened [7]. The ulnar nerve at the elbow is usually involved causing clawing of especially the ring and little finger, and is characterized by metacarpophalangeal joint hyperextension and flexion of the proximal and distal interphalangeal joint.[8] Initially, ulnar nerve involvements first cause sensory impairment. Then there is gradual motor incapacitation involving the intrinsic muscles supplied by the ulnar nerve. This causes hyperextension of the metacarpophalangeal joint and flexion and proximal and distal interphalangeal joint. [9] Among the reconstructive surgeries to replace the action of intrinsic muscles, the most common one is the Flexor digitorum superficialis muscle. The first to do it was Stiles in 1922 where FDS was passed dorsally and split with each half sutured to Extensor digitorum communis. [10] This was modified by Bunnell, where FDS was split and passed to the transverse fibers of each finger intrinsic equipment.[11] Brand later revised it to the modified Stiles–Bunnell tendon transfer in which long-finger FDS is cut and split into four slips and passed along-track of the lumbricals, volar to deep, transverse metacarpal ligament, to insert along the lateral bands or into the proximal phalanges[10,12]. Deformity correction involves stopping hyperextension at the metacarpophalangeal joint so extensors extend the interphalangeal joint, and flexion of the proximal phalanx of the fingers can happen. This study aims to evaluate the functional outcomes in the patients with leprotic claw hand operated with the zancolli lasso procedure. The reason why the Zancolli lasso procedure was chosen because this surgery is easy to do with low learning curve with appropriate results. This study aims to assess the deformity correction, grip strength and range of motion in determining our results. The need of this study is to ascertain that the surgery, being easy with minimum training, can be done even in smaller hospitals with less infrastructure at hand and still gives good correction in deformity and improves the patients' functional outcome. In the Zancolli lasso procedure, the flexor digitorum superficialis of the middle finger is divided into 4 slips (1 for every finger) and refixed to itself after passing through the proximal A1 pulley.[13,14,15] (Figures 1 & 2) In this study, ten patients who presented with ulnar claw hand deformity and all patients being operated on with the zancolli lasso procedure will be assessed. The need to choose this procedure is because of its uncomplicated surgery and easy post-operative physiotherapy with good results. Moreover, India is a developing nation with a shortage of doctors and a huge population. The Zancolli lasso procedure is easy to do, even in peripheral hospitals. Of all the patients who got operated on, there were seven patients whose deformity correction was good, and 66.66 % of improvement was noted in grip strength compared to the preoperative status, which will be discussed below under the results.

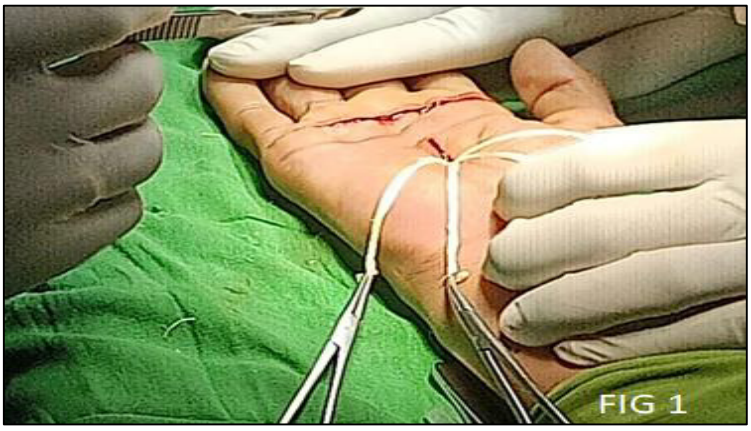

Fig 1: (Intra-Op Picture of FDS Tendon Divided into Four Slips)

In the above figure, the flexor digitorum superficialis tendon was cut and removed from the base of the middle finger along with its two slips and chiasma. Then another vertical incision was made near the proximal crease, as noted in the figure above. The cut FDS tendon was pulled out via this incision and split into four slips. Proximally in the above figure, we can note an incision at the distal crease from the second to the fifth finger, and then the flexor sheath was exposed. The split slips of flexor digitorum superficialis were then passed from the proximal vertical incision site up to the distal crease traversing via the lumbrical canals and then looped under A1 pulley and stitched onto itself.

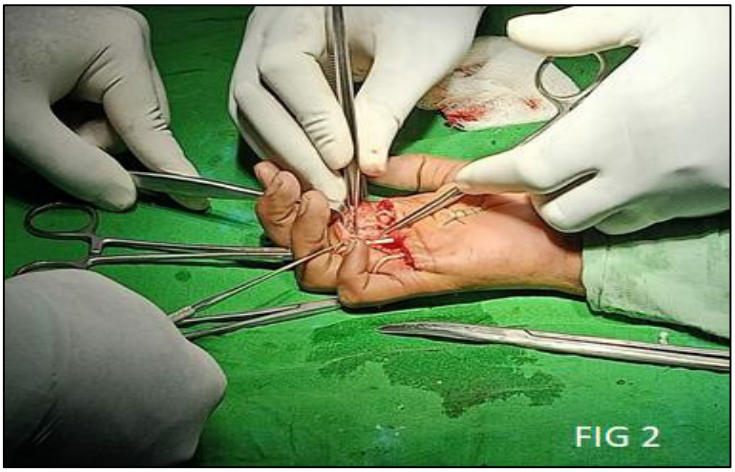

Fig 2: (Intra-Op Picture of Split FDS Tendon Brought upto the Distal Crease Incision to Be Fixed Under A1 Pulley)

The figure above here shows the four slips of the tendon of flexor digitorum profundus after being trans-positioned from the vertical incision site at the mid palmar crease and passed under via the lumbrical tunnels and brought up to the distal incision site at the distal crease is passed under the A2 pulley and then stitched on to itself with proper tension. Each slip of the flexor digitorum superficialis tendon is passed under A2 pulley of each finger and then stitched onto itself. Proper wound wash was then given, structures were closed in layers, and sterile dressing was done.

2. MATERIALS AND METHODS

From July 2020 to July 2022, 10 patients with ulnar claw hands came to Sree Balaji Medical College and Hospital, Chennai with mean age 24yrs {20-38 yrs.}and with a mean duration of disease thirty-two months {12-60 months}. Eight patients had their right hand affected, while two had their left hand affected. All the patients were claw hands secondary to leprosy with no active infection. All patients were on medications for at least six months if multibacillary and completed the regimen if paucibacillary were operated. All of the patients who came to the OPD visited independently for consultation and were not referred by NLEP. The grip strength before surgery ranged from 0 to 12 kg, with an average being 6 kg (As per Table 4). All of the patients had muscle activity of grade 1/5 on the hypothenar side, and for the thenar side, adductor pollicis muscle had a grade of 1/5 while other thenar muscles had a normal power grade. The novelty of our study is that the grip strength, range of motion, and deformity before the surgery and during the follow-up period were noted and tabulated to note the gradual change.

2.1 Surgical Procedure

All patients were operated under general anesthesia/regional block with the patient under supine position with the arm over arm board and parts painted and draped. The flexor digitorum superficialis of the middle finger was split into 4 slips (one for each finger) and fixed to itself after passing through the proximal pulley[13]. Insertion of flexor digitorum superficialis at the base of middle phalanx is cut, and both sleeves removed along with chiasma divided by making a small vertical incision at the middle crease. An incision was then made at the distal crease exposing the flexor tendon sheath of the second to the fifth finger, and the A1 pulley was identified. The Flexor digitorum superficialis, taken out at the vertical incision, is divided into four slips, passed through lumbrical canals, brought up to the distal crease, and looped under the A1 pulley of each finger, and stitched to itself with proper tension. (Figures 1 & 2) [16] Proper wound wash was given, the skin closed in layers, and then proper dressing was done. A Posterior below-elbow POP slab was applied with the MCP joint in 40-90 ° flexion and the wrist in functional position, leaving the interphalangeal joints free.

2.2 Post-Operative Physiotherapy

Sutures were removed on post-op day fourteen, and the POP slab was applied for four weeks. Patient assessment was done in the 4th week, the third month, the sixth month, and the twelfth month. After four weeks' pop cast was removed, all physiotherapy was carried on with MCP in 40-90° flexion, and then all joints were flexed and extended. Initial for four weeks cast was removed weekly, and the physiotherapist with prior hand physiotherapy experience guided physiotherapy. Then after the cast removal, the patient did the physiotherapy by himself. By 6th-week active flexion was begun using a sponge softball. The patient was asked to squeeze the softball ball slowly and release it with a count of 1 to 5. The patient was asked to do 20 repetitions with 6-8 sets per day, with 6-8 sets per day as tolerated.

2.3 Follow-Up Examination

For the follow-up examination, deformity measurement, range of motion, and grip strength assessment were done.

1. Deformity measurement: - This was done with the hand in an open position, and angle at the metacarpophalangeal joint and interphalangeal joint were measured with the goniometer and graded as good, fair, or poor.

Table 1: Deformity Grading Basing on the Angle at MCP And IP Joint		
Grade	MCP joint angle in degree	IP joint angle In degree
Good	+30 to 0	0 to 20
Fair	0 to -20	20 to 40
Poor	>-20	>40

The table below denotes the deformity measurement grading of the angles measured with goniometer of the MCP and IP joint and graded as good, fair or poor according to the degree measured. [13,17]

2. Range of motion assessment: - The assessment was done by modified brand criteria. (Table 2) Opening the hand fully, making a closed fist, and flexing the phalanges were assessed and graded. [17,18]

Table 2: Modified Brand Criteria			
	Hand Open	Fist Closed	Mechanism
Excellent	Absent residual contracture at PIP joint	Full tight fist	Full flexion of MCP joint before IP joint flexion beginning
Good	Independent extension at PIP joint and no flexion at DIP joint	Fingers close tightly, which is insufficient to hold a needle	Premature flexion of IP joint before MCP joint flexion is over
Fair	Independent extension at PIP joint with minimum flexion at DIP joint	A conspicuous gap between the base and tip of the finger	MP and IP joints flexion at a time
Poor	Any hand that does not score fair	Any hand that does not score fair	MP flexion is slower than the flexion of IP joints.

The table above is that of modified brand criteria for assessment of range of motion and then graded as excellent/good/fair/poor depending on the hand opening and fist closing. This criterion is used here for the range of motion assessment.

2.4 Preoperative Images of a Patient

Figure 3 and figure 4 above here are preoperative images of a 22-year male patient, which were taken during the assessment of the patient before surgery. Here we can note the classical hyperextension at the metacarpophalangeal joint and flexion at the right hand's interphalangeal joint of the ring and little finger. On the dorsum of the right hand, we can also see marked wasting/hollowing due ulnar claw hand.

Fig 3 & Fig 4 :(Figure above here are preoperative images of the patient with right-hand ulnar claw hand)

Figure 5 and figure 6 are preoperative images of a 22-year-old male patient, which were taken during an assessment before surgery. Here in the above image, we can note the typical deformity of hyperextension of the metacarpophalangeal joint and flexion of the ring's Interphalangeal joint and the right hand's little finger. In addition, on the volar aspect of the right hand, we can note the visible atrophy compared to the patient's normal left hand.

Fig 5 & Fig 6: (Figure above here are preoperative images of the patient with right-hand ulnar claw hand)

2.5 Post-Operative Follow-Up Images of a Patient

Figure 7 and figure 8 are post-operative images of the patient, which were taken during follow-up. The patient had right hand ulnar claw hand as seen in figure 3-6. The patient was then operated with the zancolli lasso procedure, where the split FDS tendon was passed under A1 pulley and sutured on itself. The right-hand shows the distal incision scar, which healed without any infection. In addition, the previous deformity of hyperextension of the metacarpophalangeal joint and flexion of the interphalangeal joint of the ring and little finger is corrected.

Fig 7 & Fig 8: (Figure above are post-operative images of the patient taken during follow-up)

Figure 9 and figure 10 are images taken of the patient with right-hand ulnar claw hand who was operated on with zancolli lasso procedure. Figure 9 shows the patient being able to make a fist of his right hand. The deformity of hyperextension of the metacarpophalangeal joint with flexion of interphalangeal joint of the ring and little finger, which was present before surgery, as noted in figure 3-6 is corrected. Figure 10 shows the healed scar of the right hand without any wound gaping or dehiscence.

Fig 9 & Fig 10: (Figure above are post-operative images of the patient taken during follow-up)

Figure 11 and figure 12 are images taken of the patient after surgery during physiotherapy. The patient here is doing flexion of the MCP joint, PIP joint & DIP joint with the MCP joint in 40-90° flexion. All of the physiotherapy was done under the supervision of a physiotherapist initially who has been trained for the same. Then the patient did the exercises on his own.

Fig 11 & Fig 12: (Figure above are post-operative images of the patient taken during physiotherapy)

3. STATISTICAL ANALYSIS

Paired t- test was used to assess of grip strength before and after surgery. Kruskal-Wallis test was used for assessment of open hand, fist closed, sequence of phalanx flexion, and satisfaction of patients.

4. RESULTS

4.1 Demographic Assessment

The mean age of the cases included was twenty-four yrs. {20 to 32 yrs.} with mean duration of disease thirty-two months {12-60 months}. Eight patients had their right hand affected, and two had their left hand affected. Seven patients were male, and three patients were female. The mean duration of surgery was 55 minutes, and the follow-up was up to 1 yr.

4.2 Deformity Assessment and Grip Strength

4.2.1 Deformity Assessment

Table 3: Pre And Post-Operative Deformity Measurement

	Hand Open	Pre-Op Angle			Post Op Angle			Average	Improvement
		Min	Max	Avg	Min	Max	Avg		
Ring Phalanx	Mcp	-70	0	25	-30	15	10		15
	Pip	5	75	35	0	30	15		20
Little Phalanx	Mcp	-70	-20	-30	-35	10	0		30
	Pip	20	90	45	-5	45	10		35

Table above is the measurement of angles using the goniometer at the MCP joint and IP joints of the fingers. (ref. Table 1) The deformity correction was good in 7, fair in 2, and poor in 1, respectively. The table here gives the pre-op and post-op angle at the MCP AND IP joints, along with average improvement in the ring and little finger. The little finger was seen with more improvement in the angles as compared to that of the ring finger.

4.2.2 Grip Strength

Table 4: Pre And Post-Operative Grip Strength Assessment

Pre-Op (In Kg)			Follow Up	Post Op (In Kg)			Mean Progress
Min	Max	Avg		Min	Max	Avg	
0	12	6	3 Months	2	18	8	33.33 %
			6 Months	5	25	10	66.66%
			12 Months	6	27	11	83.33%

The table here gives the grip strength preoperatively and at 3rd and 4th month of follow-up. There was an average improvement of 33.33 % at the end of 3 months, 66.66% at the end of 6 months, and 83.33% at the end of 12 months.

4.3 Range of Motion Assessment

Table 5: Modified Brand Criteria Range of Motion Assessment					
Grade	Open Hand	Closed Fist	Flexion At MCP And IP Sequence	Comparison	Mean
Excellent	6(60%)	5(50%)	6(60%)		56.66%
Good	2(20%)	4(40%)	3(30%)		30%
Fair	2(20%)	1(10%)	1(10%)		13.33%
Poor	-	-	-		

The table above is the range of motion assessment as assessed in an open hand, closed fist and flexion at MCP & IP sequence comparison; we had 56.66 % patients with excellent outcomes, 30 % percent with good outcomes, and 13.33 % patients with fair outcomes. (ref. Table 2)

4.4 Complication

One patient had a wound infection that healed on wound debridement and resuturing with proper antibiotics. Rest no other patients faced any complications.

4.5 Mean Grip Strength Changes and Range of Motion Changes During Follow-Up

Table 6: Mean Grip Strength Pre-Operative And During Follow-Up				
Pre-Op (In Kg)	4th Week (In Kg)	3rd Month (In Kg)	6th Month (In Kg)	12th Month (In Kg)
6	6	8	10	11

The above table is the mean of grip strength changes before surgery and after surgery follow-up to 12 months tabulated relating to Table 4.

Table 7: Preoperative and follow-up range of motion assessment												
Hand Position	Open hand				First closed				Flexion at MCP & IP joint			
PRE_OP	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor
	0	0	1	9	0	0	0	10	0	0	0	10
4th Week	0	0	2	8	0	0	1	9	0	0	0	10
3rd Month	0	1	2	7	0	1	1	8	3	1	1	5
6th Month	2	1	2	5	2	2	1	5	5	2	1	2
12th Month	6	2	2	0	5	4	1	0	6	3	1	0

The above table is the range of motion assessment from preoperative up to 12 months of follow-up tabulated relating to Table 2 and Table 5

Table 8: Deformity Correction During Follow Up					
Grading	Pre- Op	4th Week	3rd Month	6th Month	12th Month
Good	0	0	3	4	7
Fair	0	1	1	2	2
Poor	10	9	6	4	1

The above table is the deformity change observed from pre-op status up to 12 months and graded accordingly to Table 1 and Table 3.

Table 9: Functional Activity Assessment throughout Follow-Up					
Activity	Pre-Op (No of Persons)	4th Week (No of Persons)	3rd Month (No of Persons)	6th Month (No of Persons)	12th Month (No of Persons)
Grasp Contact	0	0	3	6	10
Pinch Contact	0	0	2	5	9
Shirt Buttoning	1	2	5	7	9
Wearing Pant	1	2	5	7	9
Knotting Shoelace	0	0	3	6	8
Eating With Hands	1	1	4	6	10

The table below here denotes the functional activity assessment of the number of patients from the pre-op period up to 12 months of follow-up. All of the functional activities were assessed along with grip strength and deformity assessment (Table 4,6,8).

5. DISCUSSION

Deformity in leprosy is due to the bacilli invading the peripheral nerves, which affect sensory and motor activity. In this study, all patients operated were cases with partial claw hand due to ulnar nerve involvement. The normal opening and closing of fingers are gone. Normally MCP joint flexion commences with total finger flexion, and all of the joints are closed simultaneously. [18,19] The deformity affects the person emotionally as well as functionally. The first target is the correction of primary deformity so that secondary deformity is not seen. Ulnar nerve paralysis results in loss of simultaneous flexion and grasp and pinches power. [20] Flexor digitorum superficialis, the principal flexor of the PIP joint, is necessary for power grasp. In the Zancolli Lasso procedure, no flexor power deficiency happens as compared to other procedures like Stiles, Bunnel, and modified Stiles-Bunnell, where the FDS is routed to the extensor side, which causes loss of power unlike the Zancolli Lasso procedure. [10,12,21] As the deformity improves over the follow-up period, the grip strength increases, which helps in improving the power grasp too.[18] Reconstructive surgery improves the hand's grasp and pinch power, which in turn helps rehabilitate the patient. [13.17] In the 10 patients included in this study all patients were assessed preoperatively to note the grip strength and muscle power. It ensured the patient had completed the required drug regimen before surgery. All the patients were started with passive finger flexion and extension exercises few weeks before the surgery to keep the joints mobile and free. The mean grip strength improved up to eleven kg after one year of follow-up as compared to the mean of six kg before surgery. (ref. TABLE 3 AND TABLE 4). The range of motion at the end of one year of follow-up in open hand was excellent in six patients, good in two, and fair in two patients. The range of motion in closed fist was excellent is five patients, good in four, and fair in one patient. The range of motion with flexion at MCP and IP joint was excellent in six patients, good in three, and fair in 1 patient. None of the patients in our study had a poor outcome of a range of motion. (Ref. TABLE 2, TABLE 5, TABLE 7). The deformity correction was good in seven patients, fair in two patients, and poor in one. (ref. TABLE 1, TABLE 3, TABLE 8). The functional activity assessment was done, and ten patients were able to do grasp contact, ten patients could do pinch contact, nine patients were able to do shirt buttoning, nine patients were able to wear pants, eight patients were able to knot shoelaces and ten patients were able to eat with their own hands.(ref TABLE 9) In this study, we used direct lassos for all surgeries where FDS tendons of the fingers or one FDS tendon is split into four slips, passed under A1 pulley, and stitched on itself. In indirect Lasso, a different muscle like Palmaris Longus, Extensor Carpi radialis longus, brachioradialis is used.[22,23,24] The direct lasso procedure was used in all our cases, and the procedure is described under surgical technique. The chances of deformity are more in the little finger because the muscle bulk and power are weaker in the little finger so while reconstruction the split FDS tendon was fixed with more tension on the small finger. Even if the index and long fingers usually do not exhibit the clawing posture, sometimes dysfunction of these digits is also present. So, the transfer is made to all four fingers regardless of clawing limited to the ring and little finger[17]. The study made by Deepak Nadkarni, D.R. Galfat, Raghvendra Sadh in the year 2015 gave excellent and good results in 90 percent of the cases. All of the cases in the study were operated with the Zancolli lasso procedure.[25] The outcome of this study is similar to the outcome obtained by us. Shrinivasan in 1973, found 80% good and excellent results in his outcome.[26]. The study was done by Turker Ozkan, Kagan Ozer, Ayse Yukse, Ayan Gulgogen which was published in 2003 in which 25 patients were included. A total of nineteen patients were operated by FDS-four tail procedure and rest five by The Zancolli lasso procedure. The mean grip strength improvement was seventy-six percent of the normal hand in the FDS-four tail group and eighty-two percent in the Zancolli lasso group. The zancolli lasso procedure was more effective in improving grip strength, according to their study.[18] A study published in 2015 by Vikas Gupta, Ashu Consul, MKS Swamy had fifteen patients with good outcomes, three with fair, and two with poor outcomes of deformity correction.[13] Studies done in Sree Balaji Medical College and Hospital had a similar outcome as that of the studies mentioned above but with an addition of pre-op and follow-up assessment of the grip strength, range of motion and deformity assessment along with that of functional activity assessment. The ideal candidates for the surgery have patients aged 15-45 yrs. The ideal duration is with the disease of a minimum one year. The patient should have completed medication if paucibacillary and received medication for six months if multibacillary with no steroid use in the last six months. The patient should also be free from systemic or local infection. The patient, if female, should not be pregnant during surgery. Physiotherapy is started 1-2 weeks before surgery to keep skin soft and joints supple and increase the strength of tendon to be transferred. Physiotherapy is quite essential after the surgery.

6. CONCLUSION

Reconstructive surgery in leprosy makes the patient feel socially accepted and helps him or her carry out basic daily activities. The Zancolli lasso procedure chosen for this study included 10 patients. The grip strength improved up to eleven kg at the end of 1-year follow-up. Furthermore, the deformity correction was good in seven patients (seventy percent of total). Lastly, the range of motion in the open hand, closed fist and MCP and IP joint in flexion also improved, as mentioned above. These factors played a vital role in improving the hand's grasping capacity and power, which helped the patient carry out all the daily activities. The Zancolli lasso being easy to operate and with less learning curve as compared with other surgeries with faster post-op recovery, should be considered when patients with ulnar claw hand come for deformity correction as this offers good correction of deformity also improves range of motion and grip strength which is proved in this study.

7. AUTHORS CONTRIBUTION STATEMENT

Dr.Pratik Mahapatra conceptualized and gathered the data and curated the data and prepared the draft of the study. Dr Vijay Narasimhan Reddy analyzed the data and draft and gave the necessary inputs for changes. Both the authors designed the manuscript together. Both the authors discussed the methodology, result and discussion and finalized the manuscript.

8. ACKNOWLEDGEMENTS

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9. CONFLICT OF INTEREST

Conflict of interest declared none.

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