Re-enablement of the neurologically impaired hand – 1: terminology, applied anatomy and assessment. Report of a Surgical Workshop held at Green Pastures Hospital and Rehabilitation Centre, November 2004, Pokhara, Nepal

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Introduction

A workshop on the re-enablement of the neurologically impaired hand was held at Green Pastures Hospital and Rehabilitation Centre, Pokhara, Nepal, with the following aims: (a) to exchange ideas and techniques between experienced leprosy surgeons from different countries and continents about assessment and surgical reconstruction of the primary and secondary impairments of the neurologically impaired hand and (b) to develop a document with best practice recommendations and areas for further research. A similar workshop was organized in 2000 on the neurologically impaired foot. The proceedings of this workshop have subsequently been published.1,2

For proper understanding of the primary and secondary impairments and their assessment, it is mandatory that there is consensus about terminology and adequate understanding of (patho) kinesiology of the hand. These will be discussed in the first part of this report. The second part of the report will discuss surgical techniques as they relate to the primary and secondary impairments.
Terminology

In the International Classification of Functioning, Disability and Health (ICF, previously ICIDH), impairments are defined as problems in body function or structure such as a significant deviation or loss.3,4 An example of impairment in body function would be loss of sensation; examples of impairments in body structure would be contractures and absorption. A ‘deformity’ would be a structural, usually visible, impairment. Activity limitations (formerly ‘disabilities’) are defined as ‘difficulties an individual may have in executing activities’. Examples in leprosy patients would be difficulty in eating, dressing or writing because of impaired hand function. ‘Disability’ is now used as an umbrella term for impairments, activity limitations and participation restrictions (formerly handicap). If a leprosy-affected person is prevented from entering a teashop or riding the bus, then there is a participation restriction (Table 1).

Primary impairments are the immediate effects of peripheral nerve dysfunction, e.g. loss of sweating, impaired sensation and weakness/paralysis. Secondary impairments are the, often avoidable, impairments that may be a consequence of the primary impairments, ulcers, absorption, contractures etc. Other, different, impairments may also follow reconstructive surgery (see companion article).

The naming of a surgical procedure is often not sufficiently informative, e.g. Zancolli Lasso operation. It is suggested that when naming a technique at least the donor muscle and insertion should be mentioned, e.g. palmaris transfer with ‘lasso’ (pulley) insertion.

Prevention of primary impairments: early diagnosis of the disease and early/adequate treatment of ‘neuritis’

Early Diagnosis of the Disease

It is generally accepted that an early diagnosis of the disease will prevent nerve function impairment (NFI) in the majority of newly diagnosed cases. Nevertheless, NFI may develop in newly diagnosed patients who reported without NFI and may increase even more in patients who reported with NFI at the time of diagnosis.5,6 It is clear that worldwide, fewer patients report with disability and nerve function impairment at the time of diagnosis.7,8

Nerve Surgery

Much has been written about techniques and the possible positive effects of nerve surgery. To date there is no evidence from randomized clinical trials that nerve surgery may be beneficial.

Table 1. Health related definitions3

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<tr>
<th>Impairment</th>
<th>Problems in body function or structure such as a significant deviation or loss</th>
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<td>Activity limitation</td>
<td>Execution of a task or action by an individual</td>
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<td>Participation</td>
<td>Involvement in a life situation</td>
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<td>Participation restrictions</td>
<td>Problems an individual may experience in involvement in life situations</td>
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<tr>
<td>Functioning</td>
<td>An umbrella term encompassing all body functions, activities and participation</td>
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<tr>
<td>Disability</td>
<td>An umbrella term for impairments, activity limitations and participation restriction</td>
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in the prevention of NFI or in the recovery of nerve function. Amongst the workshop participants, there was consensus that nerve surgery is indicated in case of nerve abscess and when there is chronic pain in the nerve not responding to medical treatment including corticosteroids.

Most leprosy workers would agree that an early diagnosis of the disease/impaired nerve function and subsequent appropriate treatment enhances the chances for prevention of permanent nerve damage. Whether nerve surgery would be of additional benefit when NFI is present at the time of diagnosis is not known. There are also patients who in spite of early diagnosis of NFI and timely instituted medical treatment do develop, or continue to lose, nerve function. Whether surgery could have prevented this is also not known from published literature. At a recent research workshop in Karigiri, India (2004), a protocol was discussed to start a multi-centre randomized trial to assess the possible benefits of nerve surgery in the prevention of nerve function impairment.

Biomechanics

A basic understanding of the biomechanics of the hand in relation to function and restoration of function is mandatory. This should play an important role in selection of technique and assessment and evaluation of outcome of surgery. For a brief review of basic hand anatomy, especially the intrinsic muscles, the reader is referred to the literature. Here we only highlight some points that are of clinical relevance as it relates to the hand with paralysis of the intrinsic muscles. The primary and secondary impairments that may be seen in the hand with paralysis of the intrinsic muscles are given in Tables 2 and 3.

**INTEROSSEI**

The interossei are the key muscles in the stabilization of the finger joints in the sagittal plane. The interossei could be considered the anti-clawing muscles of the hand. Their role in metacarpo-phalangeal (MCP) flexion/ stabilization is more important for hand function than their secondary role as abductors and adductors of the fingers.

The fingers that may not show clawing, usually the index and middle fingers, will usually claw functionally when these fingers are active in grasping. This is often referred to as hidden or latent clawing. This is easily revealed by asking the patient to grasp and squeeze the examiner’s forearm. Increased pressure will be felt from the finger tips of the index and middle fingers. The PIP joints will hyperflex and there will be limited flexion of the MCP joints. This could be called Froment’s sign of the index/middle fingers. The biomechanical

<table>
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<th>Table 2. Primary impairments of ulnar nerve palsy</th>
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<tr>
<td>1. Loss of protective sensation and functional sensibility</td>
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<tr>
<td>2. Clawing due to loss of primary finger (MCP) flexors (interossei)</td>
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<tr>
<td>3. A-synchronour finger flexion/extension.</td>
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<tr>
<td>4. Loss of ab- and adduction of fingers</td>
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<tr>
<td>5. Loss of metacarpal arch/ulnar opposition (hypothenar muscles)</td>
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<tr>
<td>6. Decreased grip strength</td>
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<tr>
<td>7. Decreased pinch strength (pulp-pulp and key-pincah)</td>
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explanation for this is the same as Froment’s sign of the thumb: insufficient flexion moment of the MCP joint. The fingers that lack interossei will have lost more than 90% of their MCP flexion power and should be included in a tendon transfer to rebalance forces in the sagittal plane. The lumbricals have minimal flexor moment on the MCP joints and their function is mainly in unresisted opening and closing movements of the fingers depending on MCP positions or movements.

MARTIN–GRUBER NERVE SHUNT

The presence of a Martin–Gruber anastomosis is often not recognized. This median to ulnar nerve shunt can be assumed in an ulnar palsy when there is paralysis of the hypothenar muscles in the presence of variable activity of the intrinsic muscles on the radial side of the hand, notably flexor pollicis brevis and the first dorsal interosseus. In the presence of such anastomosis in a combined ulnar and median palsy, there will be hypothenar paralysis and wasting of the abductor pollicis, but activity is present in the flexor pollicis brevis and the first dorsal interosseus. The presence of a Martin–Gruber anastomosis may result in less clawing of index and middle fingers and a more stable thumb in pinch activities.

THUMB IN ULNAR NERVE Palsy

There is definite weakness of the thumb in pinching in an ulnar nerve palsy. Adductor pollicis, flexor pollicis brevis, and first dorsal interosseus are all, or for the most part, ulnar innervated. These muscles are all strongly active in pinch activities. Paralysis or weakness of these muscles may show itself in Froment’s sign (IP flexion), and/or Jeanne’s sign (MCP hyperextension). Whether these signs or other secondary impairments develop, such as MCP instability and/or carpo-metacarpal (CMC) (sub) luxation, depends on such factors as hand dominance and use, duration of the palsy, configuration of MCP joint surfaces and joint laxity. These factors are also important to take into account when considering correction of the thumb in ulnar nerve paralysis. The role and function of adductor pollicis and flexor pollicis brevis in thumb stabilization could be compared with that of the intrinsics for the other fingers. They have a flexor moment for the MCP joint and, through the lateral band, extend the IP joint.

GRIP STRENGTH AND LOSS OF METACARPAL ARCH

Little is known about the effect of ulnar or combined ulnar and median palsy on grip strength, including pinch, nor is much known about the effect of surgical corrections for correction of intrinsic paralysis on grip strength. Yet, often surgeons and therapists alike seem to take the possible effect on grip strength into account when deciding on a surgical technique.

<table>
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<th>Table 3. Secondary impairments of ulnar nerve palsy</th>
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<tr>
<td>1. Ulcers/Scars/Absorption</td>
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<td>2. Contractures (PIP joints: skin/joint structures)</td>
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<td>3. Long finger flexor tightness</td>
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<td>4. Contracture oblique retinacular ligament</td>
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<td>5. ‘Hooding’ / attenuation of extensor mechanism</td>
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<tr>
<td>6. Habitual wrist flexion</td>
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<td>7. Z = Thumb</td>
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Table 3. Secondary impairments of ulnar nerve palsy
Antepulsion of the 4th and 5th rays at the CMC joints is a function of the hypothenar muscles. This movement secures a power grip and contributes to grip strength. Brand named the effect of the antepulsion of these rays, the ‘power house’ of the hand. Cupping of the hand, which could also be named ulnar opposition, is very important in countries in which the hand is used for eating and scooping water for drinking.

In leprosy, one study has explored the possible relationship between grip- and pinch strength in activities of daily living. Another study has explored the possible relationship between grip strength and type of tendon transfer.

It should be noted, however, that grip strength per se does not seem to be the important issue for most leprosy affected persons. Many will indicate (subjective) that grip strength has improved following surgery while, objectively, with the use of a dynamometer, it can be shown that grip strength has not changed or may have decreased. (Brandsma, unpublished data). Because the hand has a more secure and better grip, this is often interpreted by the patient as a stronger grip.

MOMENT ARMS/EXCURSION /TENSION FRACTION

The surgeon needs to have a working knowledge of the properties of the muscles of the hand. This is especially true for the ‘donor’ muscle(s) that will be used to substitute or enhance functions that are lost or need to be reinforced. The important properties of muscles in the context of tendon transfer surgery refer primarily to excursion potential and strength. Knowledge of Brand’s work is indispensable. He calculated excursion and tension generating potential for all of the forearm and hand muscles. More importantly, the surgeon and therapist should also know about moment arms and how tendon rerouting and site of insertion may affect hand function and outcome of surgery. For more detail the reader is referred to the publications by Kozin, Fridén and Lieber.

ILEP guidelines for referral for surgery

In 1999 the Medico-Social committee of ILEP published a guideline for identifying patients for referral for surgery (www.ilep.org.uk). The workshop participants felt that the guidelines should be modified in light of current views and practice. They should be very practical especially for the benefit of staff in integrated health services, who may only see a limited number of leprosy affected persons. The workshop members felt that few centres are aware of the current guidelines.

Assessment

In the selection of the surgical technique for correction of the paralysed hand, the surgeon often makes a choice on the basis of presence and degree of mobility of the hand, notably the proximal interphalangeal (PIP) joints. But what constitutes a (hyper) mobile or stiff hand?

The following is suggested:

- Hypermobile hand: in assisted extension the PIP joint(s) extend beyond neutral.
- Mobile hand: full assisted extension to neutral.
Near mobile hand/ finger: less than 10 degrees short of full assisted extension.

Stiff hand/ finger: more than 10 degrees contracture.

These suggested definitions are given with the understanding that an effective extensor mechanism is present.32,33

It is important to realize that a hand consists of four fingers, five if the thumb is included, and that therefore there could be any combination of (hyper) mobile/stiff fingers that may influence the choice of technique in a particular hand. It is good practice to compare the hand with the other hand when that hand is unimpaired.

Little is known about long-term effects of reconstructive surgery in neuropathic hands. Published research usually reports on improvement of angles or may report about grip strength. In other words, most studies only report about effects at the impairment level. Nothing is known about how surgery affects the leprosy-affected persons in their day-to-day living, the activity level, or the socio-economical level (participation level). The problems that leprosy affected persons experience may be at these levels. It may be that these will be alleviated by surgery, which is at the impairment level, but little is published in this area. The relationship between impairment and disability has been researched but not in the context of reconstructive surgery.34,35

The recently developed SALSA scale (Screening for Activity Limitation and Safety Awareness), primarily developed for patients with neuropathic limbs has some potential use.36 The scale has seven questions that relate to work and another five that have to do with dexterity. The main drawbacks of this scale to evaluate the effects of surgical interventions would be that the questions are too general, and that many activities can be done by substitution. To be able to evaluate the effect of surgical intervention it is important to take hand dominance into account and substitution, but also the condition of the non-operated hand, which may be impaired.

The Basic Activity of Daily Living Scale, developed in Karigiri, has the same drawback for evaluation of surgical interventions. This scale does not take into account whether activities are executed with the (non) dominant hand or with both hands, or if activities are done in the usual and expected manner.

The Participation (restriction) Scale also has been developed recently to assess if, and to what extent, patients with neuropathic limbs may experience participation restrictions and to be able to assess to what extent these may be remedied with rehabilitative interventions.37,38 The main draw back to use this scale to evaluate the effect of surgery would be that in many leprosy affected persons the score will be confounded by virtue of other impairments and activity limitations that determine the presence of participation restrictions.

Other scales and questionnaires in common use in hand surgery and hand therapy would often be too general, disease specific, or would not take into account that the neuropathic hand in leprosy affected persons often has loss of protective sensation. The DASH (Disability of Arm and Shoulder Hand) has become a widely used instrument in recent years in the assessment and evaluation of interventions in upper extremity pathology.39 This instrument is not culturally appropriate for leprosy affected persons in that it asks for some activities that are not commonly practised in these countries. For a review of available instruments across the three ICF domains of functioning, see MacDermid.40 It appears that for surgeons and therapists to be able to evaluate the impact of interventions across the three dimensions of disability different instruments need to be used.
Conclusions/recommendations

**BEST PRACTICE**

In the rehabilitation of neuropathic hands, which includes surgery, and its effects on the patients’ functioning, the terminology of the ICF should be used.

The naming of operations should be more informative and descriptive, e.g. palmaris longus transfer with Lasso insertion, not just Lasso operation or FDS intrinsic replacement.

The primary reason for correction of claw finger correction in dynamic (tendon transfer) procedures is the restoration of primary MCP flexion. The term ‘lumbrical replacement’ is a misnomer.

In most ulnar nerve palsies, four fingers should be corrected even though there may be only two-finger clawing present (overt clawing). Index and middle finger primary MCP flexion will be weak in most cases due to paralysis of the ulnar-innervated interossei and they will frequently progress to clawing (hidden or latent clawing).

It is recommended that the current ILEP guidelines for identifying patients for referral for surgery be updated/rewritten.

To confirm the long-term result of surgical intervention, assessment should be carried out for at least 2 years postoperatively.

Surgeons and therapists treating persons with neuropathic hands should have a good understanding of the biomechanics of the hand and how the various reconstructive procedures may affect hand function.

**RESEARCH**

A randomized clinical trial is needed to assess possible beneficial effects of neurolysis on nerve function recovery in leprosy neuropathy.

Instruments (or parts of instruments) need to be identified, or otherwise developed, to be able to evaluate the effects of surgery for intrinsic paralysis in the hand with peripheral paralysis and loss of sensation at all three levels of disability.

Now that a dynamometer is available that can quantitate the strength of individual finger movements, research should be done to determine to what extent the different techniques to correct claw finger deformity determine grip and pinch strength.\(^{41,42}\)

**References**
