

Impairment of hand function and loss of earning capacity after occupational hand injury: prospective cohort study

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Objective. To examine the loss of earning capacity and permanent impairment of a cohort of male patients who had experienced finger amputation due to occupational injury.

Design. Prospective cohort study.

Setting. University teaching hospital, Hong Kong.

Patients. Twenty-eight male patients aged 26 to 55 years who presented with work-related finger amputations in their dominant right hand from 1990 through 1991.

Main outcome measures. Type and extent of amputation, and hand function before and after (mean, 11 months; range, 8-16 months) the patients' return to work. Assessment results were compared with patients' percentage loss of earning capacity as calculated using the scale described in the Employees' Compensation Ordinance of Hong Kong.

Results. Patients with injuries that corresponded to a loss of earning capacity of 12% or greater had a significant impairment in their hand function ($P<0.05$); the hand function of this group after their return to work significantly improved ($P<0.05$). There were no significant differences between the loss of earning capacity scores as calculated by the Hong Kong, American Medical Association, or Indian Medical Association scales.

Conclusion. Patients whose loss of earning capacity is 12% or greater are likely to have significant long-term impairments of hand function. Thus, a more intensive rehabilitation programme should be provided to this group.

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Key words: Accidents, occupational; Amputation; Disability evaluation; Finger injuries; Hand injuries

Introduction

Hand functions are measured by using a range of standardised physical assessments and functional tests.¹ Physical assessments include measuring the range of hand motion, strength, sensation, and physical dimensions of the hand. Functional tests aim to evaluate the coordination and fine dexterity of the hand while performing certain standardised tasks, as well as the functional sensibility. Work performance is assessed by using special tests that simulate work situations.² An objective measurement of hand function is very

important in documenting the progress of the recovery from an occupational hand injury, and in determining the presence and extent of any residual permanent impairment. When an overall assessment of hand function is required, especially during compensation claims, an index of impairment for the whole hand and the whole person is usually calculated. The index is expressed as the 'percentage loss of earning capacity' (LEC) in Hong Kong, as stipulated in the Employees' Compensation Ordinance.³ The First Schedule of the Ordinance specifies the LEC percentages conferred to various types of injuries. This assessment scheme has undergone little revision, despite frequent amendments in the administration and pecuniary aspects of compensation.⁴

Different countries use different schemes to assess the loss of earning capacity, which is also described as the amount of permanent impairment.^{5,6} There have been only a few studies of the reliability of these assessment schemes, but none of the studies compare

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the various schemes available.^{7,8} We compared the percentage LEC or permanent impairment of a group of patients who had experienced finger amputation through occupational injury, as calculated by using three different assessment schemes. We also compared the LEC scores with the results from standard hand function tests. Changes in hand function after the patients had returned to work were also determined.

Methods

Patient selection

We studied male patients who had presented to the Department of Orthopaedics and Traumatology at the Prince of Wales Hospital from 1990 through 1991 with finger amputations in their dominant right hand. All cases of amputation in this closely defined group were occupational hand injuries and all patients were initially admitted to the Prince of Wales Hospital for treatment. Patients with neurovascular or tendon injuries in other fingers were excluded, so that only one type of finger amputation was assessed. Bilateral cases of injury as well as thumb amputations were also excluded. Hand dominance was defined as the hand that the patient used regularly for the following eight common daily tasks: tooth brushing, opening the water tap, writing, using chopsticks, turning a screw with the fingers, using a screw driver, using a spanner, and playing racket sports.

Hand function tests

The first assessment of hand function was performed after a full course of rehabilitation had been completed and at a time when the patient was ready to return to work. The second assessment was performed by the same assessor after the patient had returned to work, at an average of 11 months later.

The hand function tests that were used in both assessments included measuring the range of motion of the joints in the hand, grip strength (three types of grips), sensibility (two tests), and joint stability, as well as the O'Connor test and a screw-turning test. Subjective symptoms of stiffness, instability of joints, scarring, and pain were also recorded. Normative data were obtained from a control group of 80 males who had no hand injuries and who were matched by age, occupation, and hand dominance. In addition, hand function data from each patient's uninjured hand were also obtained.

The O'Connor test is a standard functional test that was designed to evaluate single-hand fine manipulation skills; thus, it is particularly valid for assessing

the effects of single-hand finger amputations.⁹ Each patient was asked to pick up three small metal pins simultaneously, by using either the finger tips or a pair of forceps, and to place the pins into round holes that were arranged in rows in a wooden board. The time required to fill 100 such holes was recorded. The times taken to fill the first 50 holes and the next 50 were recorded separately, and an overall score was calculated according to a standard chart.

The screw-turning test utilised a special box-like piece of equipment that consisted of a 2-cm knob protruding from one end and a timing device. A constant resistance was provided to the knob and each patient was asked to turn the knob with his finger tips. The time required to complete 10 turns was recorded and the average time from three trials was calculated. The aim of this test was to assess the strength of the tripod grip formed by the thumb and the two most radial fingers while performing repetitive turning motions. The action is similar to turning a screw or bolt with the fingers, which is a commonly required skill in a manual occupation.

The percentage LEC was calculated according to the First Schedule of the Employees' Compensation Ordinance of Hong Kong.³ The degree of impairment was also calculated using two other schemes: that developed by the American Medical Association (AMA),⁵ and that recommended by the Indian Medical Association (IMA).⁶ (Copies of these three schemes are available from the authors.)

Statistical analysis

The Student's *t* test was applied to parametric data and the Bonferroni correction method was used to compare the study and control groups. A paired Student's *t* test was used to compare the results from the first and second assessments. The Mann-Whitney *U* test was used for non-parametric data and the Wilcoxon matched pairs signed rank sum test was used to compare non-parametric data between the two assessments. Comparability between the results from the patient and control groups was tested with the Chi squared test.

Results

In the 9-month enrollment period, 65 patients had been admitted to the Prince of Wales Hospital for finger amputations; 28 male patients who had presented with amputations in their dominant right hand were included in the study. The mean age was 37 years (range, 26-55 years). The occupations of these patients were as follows: carpentry (n=6), manufacturing

Table 1. Distribution and type of finger amputations

Extent of amputation	No. of patients (n=28)			
	Index finger	Middle finger	Ring finger	Little finger
Distal phalanx	6	5	4	1
Middle phalanx	5	6	5	1
Proximal phalanx	1	1	1	0
Total	12	12	10	2

industry (n=10), construction site labour (n=2), machine operation or repair (n=5), and other manual work (n=5). Twenty (71%) patients had a single finger amputation and eight (29%) had experienced amputation of two fingers. A total of 36 fingers had been amputated. The index and middle fingers were each involved in 12 cases, the ring finger in 10, and the little finger in two. The distribution of amputated fingers and level of involvement are shown in Table 1. The most severe injury occurred in one patient who had one finger completely amputated as well as one phalanx amputated from another finger. The average duration of treatment and rehabilitation was 5.3 months (range, 3.0 to 9.0 months).

Hand function assessment

The initial and subsequent hand function assessments are shown in Table 2. Twenty-two (79%) patients completed the second assessment at an average of 11 months (range, 8-16 months) after their return to work. At the first assessment, all tests showed evidence of marked impairment of hand function when compared with the control group or the uninjured hand. The overall results of the second assessment did not show a significant difference from the first. A high percentage of patients reported stiffness (79%), instability (25%), and scarring (32%) at the first assessment, and the mean self-reported pain score was 4.3 on a visual analogue scale of 1 to 10. These symptoms did not correlate with the LEC values or results from other hand assessment tests.

Percentage loss of earning capacity

The mean LEC values of the whole study group were as follows: Hong Kong scale,³ 12.3% (standard deviation, 7.0%); AMA scale⁵ 14.5% (10.1%); and IMA scale⁶ 14.1% (9.0%). The median values were 13.0%, 12.0%, and 11.5%, respectively. There were no statistically significant differences between these values.

Injury classification

The various hand injuries were classified as being either major or minor, using 12% LEC (Hong Kong scale) as the cut-off value, because this value corresponded to the amputation of one whole finger or the amputation of two or more phalanges of two fingers. This level of LEC also approximated to the median degree of impairment that was determined using the three different scales. The mean LEC of the patients with major injuries (n=15) was 17.7% (range, 12%-25%) and that of the patients with minor injuries (n=13) was 6.1% (range, 4%-11%) [$P<0.05$].

At the first assessment, the results of the patients with major injuries were much lower than those of the controls. For patients with minor injuries, only the power grip results were lower than those of the controls ($P<0.05$), the results of the other assessments were similar to those of the controls (Table 3a). At the second assessment, there were significant improvements in some aspects of hand function of the patients who had had major injuries: an average of 38% increase in power grip and tripod grip and an improvement

Table 2. Assessment of hand function before and after patients' return to work

Hand function test	Test score		
	Initial assessment (n=28)*	Second assessment (n=22) [†]	Controls (n=80) [‡]
Power grip (kg)	21.9 (64%) [§]	22.1	42.3
Tripod pinch (kg)	8.1 (70%) [§]	9.7	11.8
Pulp pinch (kg)	5.4 (58%) [§]	5.9	9.7
Two-point discrimination (mm)	6.5 ^{xx}		6.1 3.9
Weinstein-Semmes monofilament test	2.3 ^{xx}		2.0 1.5
O'Connor test (score)	4.4 [§]	4.2	5.5
Screw turning (sec)	18.4 [§]	17.5	9.2
Total active range of motion (%)	85.1	87.0	100.0

* Figures in parentheses represent the percentage strength compared with the uninjured hand

[†] Mean, 11 months after return to work; range, 8-16 months; results of the first and second assessments showed no significant differences

[‡] All assessment results were significantly different from control values

[§] Difference between results of injured and uninjured hand was significant ($P<0.05$)

^{xx} Difference between results of injured and uninjured fingers in the same hand was significant ($P<0.05$)

Table 3. Comparison of hand functions between patients with major and minor injuries*

(3a) Initial assessment [†] Hand function test	Test score for patients with	
	Major injury (n=12)	Minor injury (n=10)
Power grip (kg)	16.5 (39%) [‡]	28.5 (67%) [‡]
Tripod pinch (kg)	5.2 (44%) [‡]	11.4 (97%)
Pulp pinch (kg)	4.6 (47%) [‡]	7.0 (72%)
Two-point discrimination (mm)	8.3 [‡]	4.5
Weinstein-Semmes monofilament test	2.7 [‡]	1.5
O'Connor test	3.2 [‡]	5.2
Screw turning (sec)	22.9 [‡]	13.1
(3b) Second assessment Hand function test	Test score for patients with	
	Major injury (n=12)	Minor injury (n=10)
Power grip (kg)	20.9 (49%) [§]	25.3 (60%)
Tripod pinch (kg)	7.8 (66%) [§]	11.5 (98%)
Pulp pinch (kg)	4.0 (41%)	8.1 (84%)
Two-point discrimination (mm)	8.5	4.5
Weinstein-Semmes monofilament test	2.0	1.0
O'Connor test	4.0 [§]	5.0
Screw turning (sec)	23.1	14.1

* Figures in parentheses represent the percentage strength compared with the uninjured hand

[†] All results between the two groups at the initial assessment showed significant differences (P<0.05)

[‡] Result was significantly different from the control value (P<0.05)

[§] Result was significantly different from that of the initial assessment (P<0.05)

in the O'Connor test performance. No improvements were detected at the second assessment for patients who had had minor injuries (Table 3).

Discussion

The importance of accurately documenting the outcomes of injuries and their management has been appreciated in recent years.^{1,10} The extent of hand functions such as the range of motion, strength, and sensation should be assessed and documented. The AMA scale measures the extent of amputation of an injured finger and any loss of motion in adjacent joints, and converts the measurement to an overall degree of impairment of an individual.⁵ In contrast, the IMA scheme addresses many different aspects of grip, sensation, strength, deformity, cosmesis, as well as complications arising from injury or treatment⁶; it is the most comprehensive assessment scheme. However, the application of the IMA scoring system seems to be limited to use in India.

Although it was customary to describe injury outcome with a summative score, this practice is not advisable for the accurate documentation of hand function.¹ A summative score misrepresents data and cannot provide a complete description of the nature and extent of an individual's impairments. An overall index in terms of percentage LEC or impairment is usually required when an individual makes a compensation claim. Such an index should take into account

impairments of different parts of the body and should be easy to comprehend and implement. The LEC system described in the First Schedule of the Employees' Compensation Ordinance of Hong Kong represents a straightforward 'anatomical' approach, but does not provide an accurate assessment of the deficiency in hand function. The correlation of this index with more comprehensive measurements of hand function has not been reported in the literature. We have attempted to find the correlation in this study. We compared the percentage LEC or impairment of patients, as measured by the Hong Kong, AMA, and IMA scales. No statistically significant differences between the results were found. This finding may not be surprising, because finger amputations are anatomical and the extent of tissue damage is usually localised and defined. Such injuries and their compensation claims are readily assessed.¹ Thus, for this type of injury, the Hong Kong assessment scheme is suitable. Nevertheless, it is necessary to study other injury categories such as fractures, tendon injuries, or nerve injuries to see if the Hong Kong scheme is still reliable and whether using different schemes gives concordant results in these situations.

Another concern is whether an index of impairment can truly reflect the degree of deficiency in hand function. The assignment of the degree of impairment (percentage LEC or permanent impairment) for the different schemes currently available is empirical and almost arbitrary. Only a few studies have investigated

the reliability of different impairment assessment systems. In 1982, a study of the AMA scheme suggested that the scheme has a high reliability,⁷ although a recent study using better-developed assessment technology and a simulation of a patient's disability has cast doubt on the validity of the AMA scheme.⁸ The Hong Kong LEC scale has received little modification but has been assumed to be a practical and reasonable assessment method. This study shows that there is a significant positive relationship between the percentage LEC and impairment of hand function. When the injuries were classified as being either major or minor, using 12% LEC as the cut-off value, there was a significant difference in the hand function test results between the two groups. At the initial assessment of patients who had had minor hand injuries, only the power grip was weaker than that of the uninjured hand (67%). For the patients who had received major injuries, all test results were much lower than those of the uninjured hand: power grip, 39%; tripod pinch, 44%; and pulp pinch, 47%.

There was also a significant difference between the two groups of patients at the second assessment. While there was no change in hand function test results of the patients who had had minor injuries, those who had received major injuries showed improvement in their power grip (49% of the result achieved by the uninjured hand), tripod pinch (66%), and the O'Connor test results (Table 3b). These results suggest that minor finger amputations recover more quickly and more completely than do major amputations.

The differences in hand function test results between the patients of each injury group cannot be explained entirely by the difference in LEC value. According to the AMA scheme, a reduction in strength of 60% will amount to 30% impairment of the upper extremity or 18% impairment of a whole individual.⁵ There is thus a tendency for the LEC value to underestimate the impairment caused by more severe injuries. We suggest that finger amputations that rate above 12% LEC should be assessed by using a more detailed hand function test method. It is also necessary to compare other categories of injuries to see whether any correlation exists between the percentage LEC and the impairment of hand function. Currently, the work capacity of an injured worker can be measured objectively by using methods that simulate certain conditions, such as the Valpar tests, or by using computerised equipment.² When more data on work capacity have been collected from patients and compared with the percentage LEC, it may then be possible to make logical modifications of the LEC assessment scale.

It is possible that the patients recovering from major injuries initially worked at a lower workload and gradually increased their work capacity. This is an important aspect to explore further since a gradual or graded return to work may prove to be a useful rehabilitation strategy for patients. Such an approach has been reported to be successful for some patients.¹¹ Having an on-site training or reconditioning programme for hand-injured patients has also been reported to be beneficial.¹² In addition, other factors besides proper surgical management are known to influence the potential to return to work.¹³ For example, occupational hand injuries have been associated with significant psychological adjustment problems.¹⁴⁻¹⁶ Addressing these factors and refining physical impairment grading systems will help improve the long-term treatment of patients who have received hand injuries.

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