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## **Importance of hand impairment measures on return to work among industrial workers with zone II flexor tendon repair**

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**Abstract**---Introduction: Hand injuries are one among the commonest yet the most serious occupational trauma among industrial workers leading to impairment of the hand as it affect the return to work (RTW) and sometimes may even cause permanent dysfunction leading to disability. This study investigated the importance of hand impairment measures on RTW and the overall hand impairment measures among industrial workers with Zone II Flexor tendon repair. Methods: Seventy-six subjects with industrial hand injury were recruited in this study to answer the RTW questionnaire and hand evaluation was performed on their affected hands. RTW outcomes assessed whether the subjects successfully returned to the same work, either from a job change, job modification or salary reduction, and the length of the time taken to return to work (TRTW). The hand impairment measures included the hand impairment ratio, total active motion loss, grasp power loss, lateral-pinch power loss, and palmar-pinch power loss. Results: The result of the study indicated that grasp power loss was a significant predictor for the length of TRTW. Besides, the hand impairment ratio was also found to have mild significance influence with TRTW. Conclusions: This study presented the importance of hand impairment on RTW outcomes which should be considered to enable the subject to get back to their work as early as possible.

**Keywords**---return to work, Zone II, tendon repair, Hand evaluation, time to return to work, power grip.

## Introduction

Hand injury is one of the commonest and serious occupational injuries that can result in impairment and at times leading to permanent dysfunctions which not only impede the daily activities of the worker, but also have a direct impact on their return to work (RTW) outcomes.<sup>1-3</sup> Flexor tendon injuries are one of the most common industrial hand injuries occurring due to an increased industrialization around the globe.<sup>4</sup> Usually, among hand injuries the flexor tendon is the most common clinical presentation with or without other associated injuries to the bone and neurovascular structures caused by road traffic accident, industrial accident; glass cut or knife cut and occasionally results in avulsion injuries as well.<sup>5</sup>

The prevalence of flexor tendon injuries in an Indian population context is still lacking and is under research.<sup>4</sup> A study from the USA estimates an incidence at about 14/100,000-person per years,<sup>6</sup> while a study among the Finnish population puts the figure at 7/100,000-person years.<sup>7</sup> The majority of the hands are either crushed, clamped, rolled-in, or cut or sawed by tools, resulting in impairment and disability. For a worker with a hand injury, RTW is critical to gain economic productivity.<sup>8,9</sup> Literatures have revealed the significant economic and labor costs of hand injuries in today's society.<sup>10,11</sup> As a result, the RTW of workers with hand injuries has gradually piqued the interest of governments and insurance companies. Although the determinants of RTW outcome are complex; physical factors, psychosocial factors, and employment factors,<sup>12,13,14</sup> hand function components remain the most important components to be considered. Research on the RTW outcome of workers with hand injuries has, to our knowledge, mostly focused on individuals with peripheral nerve injuries after certain interventions.<sup>14,15,16</sup>

These studies found that injury-related variables such as the persistence of symptoms and complications, the level of injury, sensory as well as strength recovery, and other nonphysical variables such as age, level of education, job type, and compliance with hand therapy influenced RTW outcomes. Less emphasis was placed on the relationship between RTW outcome and hand impairment measures in workers who had suffered a Zone II flexor tendon injury and who has undergone tendon repair. Hand impairment measures, in fact, can infer the limitation and residual ability of an injured hand and are thus important references in work rehabilitation and insurance reimbursement. Several studies<sup>17-20</sup> reported that the initial anatomy severity of hand injury could refer to the final hand function and disability after maximal recovery. Furthermore, the hand impairment measures at the final plateau may be important determinants of the RTW outcome. Understanding the relationship between RTW outcome and hand impairment measures can help to determine which measurement parameters accurately reflect the RTW possibility and provide further discussion for appropriate prediction via hand impairment evaluation.

For hand therapy and work rehabilitation, a clinical hand evaluation that includes the joint range of motion of the fingers, and strength of different prehension is commonly employed.<sup>21,22</sup> The American Medical Association (AMA) published "AMA Guides to the Evaluation of Permanent Impairment" (AMA Guides) in 1971, and it has undergone several revisions since then.<sup>23,24</sup> The AMA Guides assess hand damage primarily in terms of amputation level, sensory loss location, and active range of motion in the wounded hand. In order to reflect total hand impairment, the guidebook provided not only the measuring method, but also the scales and formulae to transform the impairment components into a hand impairment ratio (HIR). Although the AMA Guides were not designed to determine disability and compensation, the impairment ratio and its measurement methods, with some minor modifications, have frequently become a primary reference in the consideration of disability level and labor reimbursement in various areas for many years.<sup>25</sup>

The impairment rating's reliability and validity, as well as its functional sensitivity for patients with lower extremity fractures, have been established.<sup>26,27</sup> However, there hasn't been any research or reporting on the relationship between the HIR and other clinical hand measures and RTW outcomes. The major goal of this study was to compare and contrast hand impairment measurements, such as HIR, in predicting RTW results for employees who had suffered a catastrophic Zone II flexor tendon injury. Traditional hand evaluations employed simple tools like tape, caliper, Goniometer, and dynamometer to quantify and offer objective evidence of hand disability.<sup>28, 29</sup> As a result, the goal of this study was to determine the importance of hand impairment measurements on RTW in employees with Zone II flexor tendon repair.

## **Methods**

### **Subjects**

The study recruited patients who suffered industrial hand injury of Zone II flexor tendon and who were admitted for tendon repair surgery from January 2019 to December 2021 at a Institutional based rehabilitation center in southern Chennai. The patients who were at least 6 months post-injury and clinically stable following the surgical procedure and hand rehabilitation were included into the study. Patients with history of other severe hand injury, amputation, peripheral nerve involvement and difficulty with communication (i.e. language barrier) were excluded from the study. The study proposal was evaluated by the ethical committee of Saveetha Institute of Medical and Technical Sciences and was approved on 10/11/2020 with approval number as 002/10/2020/IEC/SMCH. The study was also registered under the Clinical Trials Registry of India under the reference no CTRI/2021/07/035275. After obtaining written consent, seventy-six patients (67 males and 9 females) aged from 20–60 years participated in the study. Sixty nine of the patients had injury in the right hand and the remaining seven in the left hand.

Table 1  
The demographic background and RTW information

	All n=76	RTW level			Salary Reduction		TRTW n=69 Mean(SD)
		RTW without job change n=51	RTW with job change n= 18	No RTW n= 7	No n=58	Yes n=11	
Age							
Mean (SD)	42.2 (11.2)	40.2(12. 5)	37.8 (12.4)	32.8(17. 7)	40.5 (12.3)	41.8(10. 6)	-
Gender							
Male	67	47	16	4	63	10	11.5 (13.2)
Female	9	4	2	3	5	1	23.2 (25.8)
Education level							
Elementary school	19	13	4	2	13	4	21.8(26.0)
Senior School/ Vocational training	41	32	5	4	33	4	12.2(14.4)
College	16	6	9	1	12	3	9.2(10.1)
Injured hand							
Right(dominan t)	69	48	15	6	55	8	10.7 (12.4)
Left (non- dominant)	7	3	3	1	3	3	12.7 (13.4)

Demographics of the participants and their RTW information are displayed in Table 1. Sixty-three subjects (82.89%) had hand trauma due to machine crushing and clamping as well as rolling-in. Thirteen subjects (17.10%) injured their hands by cutting or sawing while operating tools. Although they had involved various digits and hand sites with different severities in their occupational injuries, all were reported to reach the stable and maximal recovery after operation and rehabilitation. The average time interval between injury onset and assessment was 11.3 months (SD: 4.1 months)

### Documentation of Return to Work

The demographic information, employment history before and after the injury, economic level, and self-reported work status were all investigated using a questionnaire. The RTW results were represented by three key factors for analysis. The RTW level divided the subjects into three categories: RTW without job change, which implied that the workers had to modify their jobs due to functional limitations; RTW with job change, which implied that the workers had to modify their jobs due to functional limitations; and no RTW, which implied that they had lost the ability and confidence to work. If the patients' salaries were reduced following the hand injury, it was determined if they would be able to work

again after recovery. Time to RTW was calculated from the time the individual was injured until the day he or she returned to work (TRTW). TRTW was formerly thought to be an objective result of RTW.<sup>1</sup> The lower the TRTW, better the RTW outcome.

### **Measurement of Hand Impairment**

The following evaluation procedures were done to assess the impairment status of the injured hands at their final stable state

- A picture of the wounded hand was taken to document its overall appearance, skin condition, palm arch, and deformity.
- Universal Goniometer was used to measure the active and passive ROMs of the joints of the affected hand.
- The aforementioned data was converted into an HIR, using 100 percent as the entire disability of a hand, as per the AMA Guides.
- A JAMAR dynamometer and pinch meter, was used to measure and determine the grip power (GP), lateral-pinch power (LP), and palmar-pinch power (PP) of both the injured and intact hand. The measurement were taken according to Mathiowetz et al<sup>30</sup>'s technique with the subject in sitting with shoulder adducted and neutrally rotated, elbow flexed at 90 degrees, and his forearm and wrist in a neutral position. The average of three trials was taken. The subject was instructed to produce an ideal cylindrical grasp with thumb opposing all fingers to obtain a mean grasp power. The pinch meter was placed between the thumb and the lateral aspect of the subject's index finger with the same arm posture to measure the ideal lateral-pinch power. The pinch meter was inserted between the thumb pad and the pads of the index and middle fingers for the palmar-pinch power test. Both pinch powers were averaged over three trials. The power loss was calculated by dividing the deficient power of the wounded hand by the power value of the intact hand to arrive at a percentage loss, with 100 percent representing entire loss. The 10% corrections for hand dominance have also been tweaked.<sup>31</sup> The non-dominant hand on the left was expected to be 10% weaker than the dominant hand on the right. 0 percent strength loss was seen when the injured hand was stronger than the non-impaired hand.<sup>16</sup>
- An Universal Goniometer, was used to calculate the total active motion range loss (TAML) using the ROM data. The total active motion ranges has been used to evaluate digital performance for decades.<sup>32</sup> The TAML was calculated as the percentage of the deficient range compared to the normal range.

### **Data Analysis**

The demographic background and hand impairment measures of the participants with various RTW outcomes were depicted using descriptive statistics. To compare different RTW groups, chi-square analysis was employed for nominal variables, and t-tests and ANOVA were utilized for continuous variables. The correlation coefficients were computed to evaluate the link between the hand impairment measurements and the TRTW. All tests were two-sided, and statistical

significance was defined as a P value of 0.05. The SPSS statistical software was used to analyze the data.

## Results

### RTW Levels and Salary Reduction

The demographic statistics and RTW information (Table 1) reveal a total of 51 subjects returned to their previous work without any modification, while 18 subjects returned to work at the same company with a job change/modification. Seven subjects in this study did not return to work at all after their hand injury; three had a moderate hand impairment (HIR: 35.4%, 37.6% and 39.8% respectively), were aged above 50 years old. The remaining four subjects had slight hand impairment (HIR below 13%), were between the ages of 20–25 years old, and decided leave the job under personal grounds. Out of 76 subjects who returned to work, 58 subjects did not have a salary reduction, but 11 subjects has salary reduction post injury. However, the chi-square analysis showed a large significant difference in salary reduction between the two RTW groups with and without job change ( $P = .001$ ).

Table 2  
The distribution of the hand impairment measures of different RTW category

	All n=76	RTW level			Salary Reduction	
		RTW without job change n=51	RTW with job change n= 18	No RTW n= 7	No n=58	Yes n=11
Hand impairment ratio	16.3(15.4)	13.2(13.1)	20.8(18.6)	17.1(15.4)	15.6(15.4)	20.4(18.0)
Total active motion loss	15.4(14.1)	13.2(12.5)	18.8(16.8)	16.3(14.2)	14.0(13.6)	22.3(15.2)
Grasp power loss	18.4(24.6)	16.1(22.8)	20.7(26.6)	15.6(15.8)	17.4(25.6)	18.7(26.5)
Lateral-pinch power loss	15.2(21.5)	13.6(21.1)	15.8(23.3)	20.2(20.6)	14.3(21.9)	17.0(23.1)
Palmar-pinch power loss	21.4(25.4)	21.1(24.3)	23.7(26.3)	12.7(14.9)	23.7(28.2)	18.8(16.5)

The RTW group without job change tended to have no salary reduction. The distribution of the hand impairment measures in different RTW groups is shown in Table 2.

Table 3  
Correlation of hand impairment measures and TRTW (n=69)

Parameters	TRTW
Hand impairment ratio	0.32
Total active motion loss	0.26

Grasp power loss	0.47
Lateral-pinch power loss	0.36
Palmar-pinch power loss	0.38

### **Time taken to Return to Work (TRTW)**

The average TRTW of all subjects was 14.3 weeks (SD: 16.3 weeks). The means of the TRTW in different demographic groups are shown in Table 1. However, there was a statistically significant difference in TRTW between the RTW category with and without salary reduction ( $P < .05$ ), but no difference between the RTW groups with and without job change. The Pearson's correlation coefficients demonstrated that all the measured variables had a mild positive correlation with TRTW at the significant level (Table 3).

### **Discussion**

The study examined the individuals' hand impairments and identified some heuristic connections between the measured variables of hand impairment on RTW results after hand damage. The study revealed that the affected hand's grasp power decrease was found to have statistical relevance in predicting the length of TRTW for RTW workers. For the worker with a hand injury, grip power has been considered as an important component of work capacity;<sup>34</sup> subjects with less grasp power loss tended to return to work sooner than those with higher grab power loss. Bruyns et al.,<sup>16</sup> likewise found a significant difference in grip strength loss between RTW and non-RTW workers with nerve injuries in their hands. The considerable association between grab power and RTW outcome is supported by our data. Many studies have found that the actual outcome of RTW is complex and impacted by demographic factors such as age and gender.<sup>1-3, 13,15</sup> In this study, however, there were no significant variations in age, gender, education level, or damaged hand dominance among the subjects in the various RTW groups. The causes could be due to sample size limitations and skewed distribution, as well as other undetected factors such as family economic position, employer assistance, career opportunities, personal volition and confidence, and so on, which need to be investigated further. Furthermore, hand impairment variables revealed that gender had a near-significant impact on RTW, with males being more likely to receive RTW without changing jobs. It could imply a masculine advantage in the workplace, despite the fact that males are generally thought of as bread winners.

Furthermore, both the LP and PP losses were found to have a significant impact on RTW with and without a job move, although in opposite directions. The PP loss results differ from those reported in Bruyn's study<sup>16</sup> and will require further investigation. TRTW was found to be strongly associated to HIR, and GP loss after taking into account and controlling for demographic factors. A favorable connection was found between HIR and RTW in a holistic evaluation of hand disability. HIR, and TAML were all found to be significantly associated; GP, LP, and PP loss also exhibited a similar correlation. When it comes to explaining the association between HIR and TAML, the range of motion of the hand is crucial. These measurements, which have been attributed as an index for anatomical constraint, have rarely been investigated in terms of their link with RTW. The

importances of HIR with RTW results were established in this study; however TAML failed to show any meaningful correlations in the connections. As a result, HIR performed better as predictors than TAML. Clearly, the study reveals that the hand strength measures had a close relationship and influenced the results.

The current study's findings, on the other hand, included both agreement and inconsistencies from those previously published. It is strongly recommended that a more thorough examination be conducted to determine their significance in RTW. The results of this study revealed a slight link between RTW outcomes and hand impairment markers in industrial workers with hand injuries. However, the patients were chosen for convenience and were skewed toward those who were already RTW, limiting the sample size and the scope of the analysis. The data gathered from the individuals could only explain the RTW outcome in terms of job change or wage reduction, as well as TRTW. However, other social-economic circumstances that are beyond our control may have an impact on RTW levels and compensation reductions.

The subject's decision to return to work could be influenced by personal economic pressure, the employer's job offer as well as the work restriction, and individual confidence, among other factors. In the future, these aspects will need to be further investigated. This study discovered that grasp power loss was a strong predictor of TRTW and hand impairment measurements. Those who lost the least amount of grip power were able to return to work sooner than those who lost the most. Furthermore, the AMA guide revealed a substantial positive association between TRTW and motion area loss and HIR. This study looked at these hand impairment metrics to see if there was a link between them and RTW outcomes for employees with catastrophic hand injuries. The results of this study point to certain practical issues and areas of focus in occupational rehabilitation for workers who have suffered a hand injury.

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