Comparative Study on the Wrist Positions During Raise Maneuver and Their Effect on Hand Function in Individuals With Paraplegia

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Objective: To determine the appropriate wrist position in individuals with high-level paraplegia during the RAISE (relief of anatomical ischial skin embarrassment) maneuver. **Method:** Thirty individuals with high-level paraplegia were randomly selected; 15 individuals performed RAISE maneuver with extended wrist and 15 with neutral wrist. All the subjects who were at least 1 year post spinal cord injury were screened for positive carpal tunnel syndrome symptoms. All the subjects were allowed to participate in a trial of the Jebsen-Taylor Test of Hand Function to familiarize them with the test. Hand function was measured using the Jebsen-Taylor test. **Results:** During the RAISE maneuver, individuals with paraplegia weight bearing on their hands with wrists in the neutral position showed better hand function ($P < .001$) when compared to those weight bearing with their wrists in extension. **Conclusion:** Weight bearing with the wrist in neutral position is advisable for paraplegics to prevent the deterioration in hand function due to carpal tunnel syndrome. **Key words:** carpal tunnel syndrome, hand function, Jebsen-Taylor test, paraplegia

Carpal tunnel syndrome (CTS) is one of the most common peripheral neuropathies and is characterized by symptoms and complications such as pain, tingling, numbness, and weakness in the hands and wrists. One population that is particularly affected by CTS is manual wheelchair users.¹

Patients with spinal cord injury (SCI) place an inordinate amount of weight-bearing stress on their upper extremities. Impairment and disability of the upper extremity as a result of these forces has only recently been investigated. Gellman et al introduced the term *weight-bearing upper extremity* while studying disabilities of the upper extremity in patients who had SCI. An increased prevalence of shoulder impingement, rotator cuff tears, and CTS has been demonstrated in these patients.²

CTS is poorly tolerated by individuals with paraplegia, because they rely on their arms for mobility, transfers, and activities of daily living.¹ Most of the daily living activities of these individuals, including the maneuver to relieve ischial pressure that consists of rising from the seated position using the extended arms, are performed with the wrists locked in maximum

extension. The pressure that develops in the carpal tunnel during this forced extension of the wrist combined with the repetitive trauma to the volar aspect of the extended wrist while propelling the wheelchair potentially contributes to the high frequency of CTS in individuals with paraplegia.³ Thus there is a need to modify the force required to propel a wheelchair in order to preserve upper limb integrity.¹

The risk of CTS is high in occupations involving exposure to high pressure, high force, repetitive work, and vibrating tools. The classic symptoms of CTS include nocturnal pain associated with tingling and numbness in the distribution of the median nerve in the hand. The symptoms vary depending upon the severity of the disease. In the early stages, patients usually complain of symptoms due to the involvement of the sensory component of the median nerve and only later report symptoms from the involvement of motor fibers. The most common symptom of

Figure 1. RAISE maneuver with (A) neutral wrist and (B) extended wrist.

CTS is burning pain associated with tingling and numbness in the distribution of the median nerve distal to wrist. The portion of the hand involved is classically the thumb, index, and middle fingers and the radial half of the ring finger. Patients are often awoken by pain in the middle of the night and report hanging their hand out of bed or shaking it vigorously in order to relieve their pain. Patients may report pain, tingling, and numbness of the whole hand, but careful questioning will identify that the little finger is rarely involved as it is innervated by the ulnar nerve.⁴

As a way to minimize the risk for skin breakdown, individuals with paraplegia perform the RAISE (relief of anatomical ischial skin embarrassment) maneuver with the upper extremity adducted against the body, the wrist in maximum extension, and the forearm in supination.⁵ It has been proposed that this action places the arm in same position in which a traumatic event produces carpal instability.⁶ In the absence of an isolated traumatic event, chronic repetitive loading of the ligaments of the wrists may lead to carpal instability.² The risk of CTS due to improper wrist

position during the RAISE maneuver can be easily addressed in therapy by educating patients on proper technique. The purpose of this study was to identify whether there is a delay or reduction in CTS symptoms if the RAISE maneuver is performed with the wrist in a neutral position as opposed to extension.

Method

Sample

The study was undertaken at Ganga Hospital, Coimbatore. Thirty-eight individuals with high-level paraplegia (T2-T10) were selected by random sampling method and were screened for symptoms of CTS. Subjects were between 1 and 3 years post SCI. Upon screening, 18 subjects performed the RAISE maneuver with their wrists in neutral (**Figure 1A**), and 20 of the subjects performed the RAISE maneuver with their wrists extended (**Figure 1B**). The study sample was grouped into 1 of 2 groups based on the wrist position that was used during the RAISE maneuver. People

with tetraplegia were excluded to eliminate effects of the neurological deficits in the upper extremity. Patients with deformities in the neck, trunk, and upper extremity were excluded. Patients with history of hormonal problems, arthritic conditions, and systemic diseases and with present or past history of fractures and dislocations in upper limb and neck were also excluded from the study.

Evaluation of hand function

All the subjects were screened for positive symptoms of CTS using the Phalen's test, which is widely used to confirm CTS.^{7,8} For the Phalen's test, the patients were asked to hold both their wrists together in flexion for 60 seconds. Reproduction of the symptoms of numbness, tingling sensation, or pain in the region of hand supplied by the median nerve confirmed CTS.

Sense of touch was evaluated using Semmes-Weinstein monofilament testing using 2.83, 3.61, and 4.31 filaments. The mean values of the first 3 digits of the dominant hand were calculated. The Jebsen-Taylor Hand Function Test⁹ was used to evaluate the hand function of subjects in both groups. The Jebsen-Taylor test is widely used measure with standards for different age and gender; it has established validity, reliability, and capacity for detecting performance changes in tasks that resemble activities of daily living. It measures the time required to complete 7 tasks (writing, turning cards, lifting objects, simulated spoon use, stacking checkers, and moving light and heavy cans).¹⁰ In this study, writing was excluded as not all the participants were able to write due to cognitive deficits. Each subject performed the Jebsen-Taylor test 3 times; the best of the 3 scores was recorded.

Data analysis

Descriptive statistics were used to evaluate the frequency of CTS in the 2 groups. Paired *t*-test was used to evaluate the differences in Jebsen-Taylor test scores between the groups. Also, the scores obtained were compared with the normative scores of persons of the same age and sex. Significance was set at $P < .001$.

Results

Eight subjects were withdrawn from the study as they tested negative on the Phalen's test. Of the remaining 30 subjects, all had a positive result on the Phalen's test, 20 had decreased sensibility on Semmes-Weinstein monofilament test (>2.83), and 25 reported having pain at night. As summarized in **Table 1**, the group with neutral wrist position showed significantly better hand function than the group with extended wrist position.

Comparison of results for the dominant and nondominant hands showed that the group weight bearing with the wrist in neutral position showed better hand function when compared to the group with the wrist in extension. Significant difference ($P < .001$) was obtained by using paired *t* test to compare the hand function between the 2 groups.

Discussion

Many studies have been done on the prevalence of CTS in persons with paraplegia and claim that an increase in carpal pressure during the RAISE maneuver and repetitive propulsion movements are possible causes. However, this study is the first to show the quantification of deterioration of hand function associated with different wrist positions.

According to Gellman,¹¹ the average pressure when the wrist is in extension is far greater than reported by Gelberman.¹² The pressure in the carpal tunnel when the wrist is in extension is particularly important in individuals with paraplegia as many of their activities are performed with wrists locked in extension. The average pressures observed during the RAISE maneuver were even higher. Pressures when the wrist was in extension were higher than when the wrists were in flexion. Variations in pressure in the individuals with paraplegia who had or did not have CTS corresponded more closely to the position of the wrist than to the presence or absence of the signs and symptoms of the syndrome.³ The findings of Brain et al¹³ were the same. Separate studies by Rydevik and Lundborg in individuals with paraplegia found that the average pressure in the carpal tunnel while the wrist is held in extension is significantly greater than the threshold for neural

Table 1. Statistical summary of comparison between the wrist neutral group and wrist extension group

Jebens-Taylor subtests	Testing hand	Neutral wrist group (n=15)			Extended wrist group (n=15)			t value
		Mean	SD	SE	Mean	SD	SE	
Card turning	Right	6.73	0.59	0.15	8.27	0.70	0.18	7.99
	Left	7.20	0.77	0.20	8.67	0.49	0.13	6.81
Simulated feeding	Right	6.73	0.59	0.15	8.13	0.74	0.19	5.96
	Left	7.20	0.77	0.20	8.53	0.52	0.13	5.29
Picking up small objects	Right	6.40	0.83	0.21	7.73	0.88	0.23	4.93
	Left	6.80	0.68	0.17	8.07	0.70	0.18	4.46
Stacking checkers	Right	6.27	0.80	0.21	7.80	0.68	0.17	6.00
	Left	6.73	0.80	0.21	7.73	0.70	0.18	4.18
Picking up large light objects	Right	5.80	0.68	0.17	7.33	0.72	0.19	7.12
	Left	6.27	0.59	0.15	7.60	0.74	0.19	5.29
Picking up large heavy objects	Right	6.07	0.59	0.15	7.93	0.59	0.15	14.00
	Left	6.33	0.72	0.19	8.40	0.51	0.13	10.02

Note: Statistical significance is $P = .001$. Jebens-Taylor = Jebens-Taylor Hand Function Test.

viability and the pressures during the RAISE maneuver are even greater. This repetitive trauma to the median nerve also contributes to the high prevalence of CTS in paraplegic patients.¹⁴

This study focuses on the 2 wrist positions used by the individuals with high-level paraplegia to perform the RAISE maneuver and its association with the severity of deterioration in hand function using the Jebens-Taylor Test of Hand Function.

To relieve ischial pressure, individuals with paraplegia lift themselves from the seated position with extended arms and wrists locked in maximum extension. The carpal pressure increases during this maneuver; over a period of time, this continued pattern predisposes these individuals to CTS.

The results of our study show there was a significant difference ($P < .001$) between the group that performed the RAISE maneuver with wrist in extension and the group that performed with wrist in neutral position, with the latter showing better hand function.

Performance of the RAISE maneuver with wrist in extension increases the carpal pressure and causes carpal instability. Schroer² showed that there was a demonstrated association between carpal instability and chronic repetitive stress on the wrist in the paraplegic population.

Goodman et al evaluated carpal tunnel pressures in the wrist in 3 positions (neutral, 45% flexion, 45% extension) and during 2 dynamic tasks (wheelchair propulsion and RAISE). At each wrist position, paraplegic patients with CTS consistently had higher carpal canal pressure than did the group with nonparaplegic patients at the corresponding wrist position. Within each group of subjects, wrist extension and wrist flexion produced a statistically significant increase in carpal canal pressure ($P < .05$) compared with the neutral wrist position.¹⁵

Among the 6 subtests, we found that tasks of picking small objects, moving large heavy objects, and moving large light objects followed by stacking checkers showed more significance. This could be due to the fact that CTS causes difficulties in everyday activities like grasping, picking up, and holding of objects. The ability to perform precise finger manual tasks is important to avoid dropping things.¹⁶

Phalen's test was used as screening test for CTS along with the other tests, because it has proved to be reliable and sensitive in many studies. Much research has been done to prove the sensitivity and specificity of clinical symptoms in association with CTS. One of these was undertaken by Gellman et al, who evaluated the usefulness of provocative

tests (wrist-flexion test, nerve-percussion test, and tourniquet test) in the diagnosis of CTS. The wrist-flexion test was found to be the most sensitive, whereas the nerve-percussion test, although least sensitive, was most specific.¹¹ Another study by Kushner et al compared the Tinel's sign and Phalen's test. An analysis of the historical data and the comparison of the data to the Tinel's sign and Phalen's test results of 100 individuals led to the conclusion that the Tinel's sign is not useful in the evaluation of patients with CTS, whereas Phalen's test, which has a greater sensitivity and specificity, can be of use.¹⁰ A study by Koris et al recommends combining wrist flexion test and Semmes-Weinstein monofilament as the most accurate and sensitive quantitative clinical test to date for median nerve compression.¹²

Limitations

The best of the 3 scores of each subtest in the Jebsen-Taylor test was considered as against the

average of the 3 trials. Small sample size was a limitation of the study. Further studies should be performed on a larger sample.

Conclusion

This study determined that individuals with paraplegia performing the RAISE maneuver with extended wrists showed poor hand function compared to those performing the same with neutral wrists. The occurrence of CTS in this population can be reduced if they are taught to perform the RAISE maneuver with neutral wrist at the time of diagnosis. Further studies can be done to identify the long-term implications of CTS on hand function in a larger population with paraplegia.

REFERENCES

1. Toosi K, Impink B, Colinger J, Yang J, Koontz A, Boninger M. Correlation between wrist biomechanics and median nerve health parameters in manual wheelchair users. Presented at: American Society of Biomechanics Annual Meeting; August 18-21, 2010.
2. Schroer W, Lacey S, Frost FS, Keith MW. Carpal instability in the weight-bearing upper extremity. *J Bone Joint Surg.* 1996;78:1838-1843.
3. Gellman H, Chandler DR, Petrusek J, Sie I, Adkins R, Waters RL. Carpal tunnel syndrome in paraplegic patients. *J Bone Joint Surg.* 1988;70A:517-519.
4. Aroori S, Spence Roy AJ. Carpal tunnel syndrome. *Ulster Med J.* 2008;77:6-17.
5. Gellman H, Sie I, Waters RL. Late complications of the weight-bearing upper extremity in the paraplegic patient. *Clin Orthop Rel Res.* 1988;233:132-135.
6. Green DP. Carpal dislocations and instabilities. In: Green DP, ed. *Operative Hand Surgery*. 2nd ed. New York: Churchill Livingstone; 1988:875-938.
7. Shabir M. Surgical treatment of carpal tunnel syndrome. *J Postgrad Med Inst.* 2004;18:29-32.
8. Rashid M, Sarwar SU, Haq EU, Islam MZ. Tuberculous tenosynovitis: a cause of carpal tunnel syndrome. *J Pakistan Med Assoc.* 2006;56:116.
9. Jebsen RH, Taylor N, Trieschmann RB, Trotter MH, Howard LA. An objective and standardized test of hand function. *Arch Phys Med Rehabil.* 1969;50:311-319.
10. Celnik P. Somatosensory stimulation enhances the effects of training functional hand tasks in patients with chronic stroke. *Arch Phys Med Rehabil.* 2009;88(11):1369-1376.
11. Gellman H, Gelberman RH, Tan AM, Botte MJ. Carpal tunnel syndrome: an evaluation of the provocative diagnostic tests. *J Bone Joint Surg.* 1986;68A:735-737.
12. Koris M, Gelberman RH, Duncan K, Boublick M, Smith B. Evaluation of a quantitative provocative diagnostic test. *Clin Orthop Rel Res.* 1990;251:157-161.
13. Brain WR, Wright AD, Marcia W. Spontaneous compression of both median nerves in the carpal tunnel: six cases treated surgically. *Lancet.* 1947;1:277-282.
14. Rydevik B, Lundborg G. Permeability of intraneural microvessels and perineurium following acute, graded experimental nerve compression. *Scand J Plastic Reconstruct Surg.* 1977;11:179-187.
15. Goodman CM, Steadman AK, Miller CC, Netscher DT. Comparison of carpal canal pressure in paraplegic and non paraplegic subjects. *Clin Implications.* 2001;107(6):1464-1472.
16. Gehrmann SV, Tang J, Kaufmann RA, Goitz RJ, Windolf L, Li ZM. Variability in precision pinch movement caused by carpal tunnel syndrome. *J Hand Surg [Am].* 2008; 33A:1069-1075.