Clinical and Electrodiagnostic Abnormalities of the Median Nerve in US Army Dental Assistants at the Onset of Training

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ABSTRACT

Purpose/Hypothesis: Dental personnel including dentists, dental hygienists, and dental assistants have been reported as having a high prevalence of upper-extremity musculoskeletal disorders, including carpal tunnel syndrome. Previous research has not involved dental assistant students at the onset of dental training. Therefore, the purpose of this study was to determine the presence of median and ulnar neuropathies in US Army dental assistants at the onset of their training.

Number of Subjects: Fifty-five US Army Soldiers (28 female, 27 male) enrolled in the Dental Assistant (68E) course, volunteered to participate in the study. The mean age of the dental assistant students was 24±7.2 years (range 18-41 years). There were 45 right handed dental assistant students, and the mean length of time in the Army prior to dental training was 27 months (range 3-180 months).

Materials/Methods: Subjects were evaluated during the first week of their 10-week dental assistant course. Subjects completed a history form, were interviewed, and underwent a physical examination. Electrophysiological status of the median and ulnar nerves of both upper extremities was obtained by performing motor and sensory nerve conduction studies. Descriptive statistics for subject demographics and nerve conduction study variables were calculated.

Results: Six of the 55 subjects (11%) presented with abnormal electrophysiologic values suggestive of median mononeuropathy at or distal to the wrist. Five of the subjects had abnormal electrophysiologic values in both hands. Five of these 6 subjects had clinical examination findings consistent with the electrophysiological findings. The ulnar nerve electrophysiologic assessment was normal in all subjects sampled.

Conclusions: The prevalence of median mononeuropathies in this sample of Army dental assistants at the onset of training is greater than 5% prevalence reported in previous healthy populations and is less than 26% prevalence in previous research examining Army dental assistants with dental work experience.

Clinical Relevance: Median neuropathy at or distal to the wrist has been reported in dental personnel including dentists, dental hygienists, and dental assistants, and is also prevalent in this sample of dental assistants at the onset of training. Further long-term prospective research involving the impact of dental practice and techniques for reducing upper extremity injuries in dental professionals appears to be warranted.

There has been a tremendous increase during the past 20 years in the reported cases of carpal tunnel syndrome[1-3] resulting in an increased focus on occupational surveillance and screening.[2] Median mononeuropathy at or distal to the wrist or carpal tunnel syndrome (CTS) is one of a number of muscle-, tendon- and nerve-related disorders that affect people performing intensive work with their hands.[1-3] Dental personnel including dentists, dental hygienists, and dental assistants reportedly have a high prevalence of upper-extremity musculoskeletal disorders, including CTS.[4-16]

In their study investigating the presence of hand problems in US Army dental personnel, Lalumandier et

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14. ABSTRACT

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al[12] stated that 45% of the dental personnel surveyed indicated hand problems, and 25% were determined to indicate a high probability of CTS. The authors concluded that Army dental personnel are at greater risk of developing CTS than the general public.[12] Additionally, Lalumandier et al[12] found that 73% of dental assistants complained of hand problems, and a number of these dental assistants exhibited probable or classic symptoms of CTS. In a separate investigation, Rice et al[13] reported that symptoms associated with CTS were noted by 75.6% of the dental workers, 11% presented diagnosed CTS, and 53% indicated back and shoulder pain. Individuals in the dental assistants group were found to be at risk for developing upper extremity symptoms, CTS and back pain.

Previous studies by our investigative team, which included the diagnostic gold standard of nerve conduction studies, also support an increased prevalence of median neuropathies in military dental personnel. Specifically, 9 (26%) of the 35 Army dental assistants investigated were found to have electrodiagnostic abnormalities of the median nerve at or distal to the wrist (when compared to the ulnar nerve of the same hand).[15] Ulnar nerve electrophysiological function was within normal limits for all subjects examined.[15] This population of dental assistants was studied at the beginning and end of their training to become preventive dental specialists.[15,16] There were no new cases of electrodiagnostic median nerve abnormalities and no statistically significant shift of the nerve conduction values in the prevalence of median mononeuropathies following the 12-week training program.[16] Several ergonomic risk factors are also associated with CTS and include repetitiveness of work, forceful exertions, mechanical stress, posture, temperature, and vibration.[17] These risk factors may be present for dental personnel as dental instruments may cause contact stress over the carpal tunnel, and wrists may be held in awkward positions for prolonged periods.[18]

Collectively, musculoskeletal dysfunction of the upper extremities, to include carpal tunnel syndrome, are well documented in practicing dentists, dental hygienists, and dental assistants. There is also evidence to suggest that short-term dental training does not impact the electrophysiologic status of the median and ulnar nerves.[16] Unfortunately, there is a paucity of information in the literature to document the presence of CTS or upper extremity musculoskeletal dysfunction in Soldiers as they begin their didactic and clinical training program to become dental assistants. The job description for the Army dental assistant is similar to that of a civilian dental assistant. Therefore, the purpose of this study was to determine the presence of clinical and electrodiagnostic abnormalities of the median and ulnar nerves in both upper extremities in this sample of Soldiers at the onset of their training to become dental assistants.

METHODS AND MATERIALS

All Army dental assistants participating in the October through December 2008 dental assistant classes (N=94) were approached to participate in this study. Fifty-five participated, 33 declined, and 6 volunteered but did not keep their appointment for the data collection session.

Experimental procedures, risks, and subject rights were discussed with each individual before participation in the study. All subjects signed an institutionally approved written consent form. Individuals were excluded if they were pregnant. The study was approved by the Institutional Review Board of Brooke Army Medical Center, Fort Sam Houston, Texas.

A history, physical examination, and upper quarter neuromusculoskeletal screen were performed to determine the musculoskeletal status of the neck and upper extremities, and neural integrity of the median and ulnar nerves. These assessments were performed during the first week of the dental assistant training program.

History

A history was taken from each patient in questionnaire format. The history included information pertaining to demographics, medical history, military background, work experience, hand dominance, and the amount of time using a computer.

Physical Examination

As part of the evaluation process, the physical (screening) examination of each participant included assessment of active range of motion, manual muscle tests, sensory evaluation, reflex testing, and select special tests.[19,20] Specifically, active range of motion was assessed for the cervical spine, shoulders, elbows, wrists, and hands. Manual muscle testing was performed for all major muscle groups in both upper extremities. Sensory assessment was determined with light touch, vibration, and pain/pin prick assessment of the bilateral upper extremities. Light touch and pin prick sensation included the bilateral C4-T1 dermatomes. Vibration sensory testing was conducted using the Biothesiometer (Biomedical, Newbury, Ohio). Testing was performed at the dorsal 1st metacarpal and distal tip of the thumbs, long fingers, and middle fingers. Muscle stretch reflexes (also known as deep tendon reflexes) were obtained from the biceps brachii, brachioradialis, and triceps in the upper extremities. Upper extremity pathological reflexes were assessed with the Hoffman sign.

Last, the special tests of Tinel's sign of median and ulnar nerves at the wrist, Tinel's sign of the ulnar nerve at the elbow, Phalen's test, and the assessment of the radial pulses during positional changes of the upper extremities and neck (Adson's maneuver) were examined.[19,20] Additional special tests of the median and ulnar nerves were performed on both upper extremities of each subject and included the elbow hyperflexion test (EHFT) to assess for ulnar neuropathy at the elbow,[21] upper limb neural dynamic testing (ULNDT) to determine irritation of the cervical nerve roots or upper extremity nerves,[22] and wrist ratio tests that determines the ratio of both the anterior-posterior and medial-lateral widths measured at the distal crease of the wrist.[23-25]

Nerve Conduction Studies

At the time of volunteer solicitation, potential subjects were instructed to abstain from exercising for 1 hour prior to testing. Skin temperature at the wrist was measured using a digital thermometer model TM99A (Cooper Instrument Corporation, Middlefield, Connecticut), and was maintained at or above 32ºC. If skin temperature fell below this value, the wrist, hand, and forearm were rewarmed with warm towels.

The Cadwell Sierra LT electromyograph and stimulator (Cadwell Laboratories, Inc, Kennewick Washington) were used to measure the compound motor action potential (CMAP) and sensory nerve action potential (SNAP) latencies and amplitudes. The stimulating current was a monophasic pulse 0.1 millisecond long. The oscilloscope was set to a sweep duration of 2.0 milliseconds per division and a gain of 20 μV per division for the SNAPs. For the CMAPs, the oscilloscope was set to a sweep duration of 2.0 milliseconds per division and a gain of 5 mV per division. The filter settings were 10 Hz-10 kHz for the motor potentials and 10 Hz-2 kHz for the sensory potentials. The sensory latency was measured at the negative peak of the SNAP, and the amplitude was measured from negative peak to positive peak. The motor latency was measured from the negative takeoff of the evoked CMAP, while the amplitude was measured from the baseline to the negative peak of the evoked response. The obtained results were recorded manually and on computer printout.

Specific details for performing the median and ulnar nerve conduction studies (NCS) were presented in a study by Harkins et al[26] and follow procedures previously described.[15,27-30] The median and ulnar nerve palmar and digital distal sensory latencies (DSLs), distal motor latencies (DMLs), and conduction velocities were obtained from both upper extremities. All NCS procedures included measuring the anatomic course of the nerve: median and ulnar palmar DSLs (8 cm), median and ulnar digital DSLs (14 cm), and median and ulnar DMLs (8 cm). In addition to comparing median nerve palmar and digital DSLs, DMLs, and conduction velocities with a chart of normal values, comparison studies between median and ulnar palmar DSLs, digit DSLs (digit 2 and digit 5, digit 4 median/ulnar), and DMLs in the same and opposite extremities were obtained. Examination of median and ulnar latencies in the same extremity and median and ulnar latencies in opposite extremities has been shown to assist in early electrodiagnosis of CTS.[27-30]

Preventive Guidelines and Exercises for the Wrist and Hand

Upon completion of the examination, each Soldier received information regarding stretching, strengthening, resting, and nerve gliding techniques to assist in the prevention of future musculoskeletal injury. The exercises focused on the forearm, wrist, and hand. The purpose of providing upper extremity exercises (mobility, strengthening, and stretching) was to increase these Soldiers' awareness of possible musculoskeletal problems in dental personnel. Additionally, the subjects were advised to incorporate these exercises into their professional dental assistant practice.

In an effort to ensure consistency across subjects, one investigator (N.H.) collected all history data, another (S.F.) performed the physical examinations, and a third (R.M.) performed all nerve conduction tests. The neural conduction assessment of the median and ulnar nerves that were performed by researcher R.M. was directly monitored by either investigator 4 (D.G.), 5 (S.S.), or 6 (J.M.). Investigators 4 and 5 are board-certified clinical specialists in clinical electrophysiology by the American Board of Physical Therapy Specialties of the American Physical Therapy Association. Investigators 4, 5, and 6 are or have been credentialed by the US Army to perform clinical electrophysiological testing (NCS and EMG studies).

Data Management and Analysis

Descriptive statistics for subject demographics and nerve conduction study variables were calculated using Statistical Package for Social Sciences (SPSS) software version 12.0 (SPSS Inc, Chicago, IL).

RESULTS

History

Fifty-five subjects participated in this study (28 female, 27 male). The age of the subjects ranged from 18 to 45 years (mean=24±7 years). Forty-five of the subjects were right-handed. All subjects had been in the military for at least 3 months with a range of 3 to 180 months

(mean=27 months), and had completed basic combat training. Three of the subjects had college degrees, 19 had completed some college work, 31 had a high school diploma, and 2 had a GED. Twenty-three subjects were active duty Soldiers, 19 Army Reservists, and 13 Army National Guardsmen. One subject (No. 49) had previous experience as a dental assistant in a civilian setting.

The mean time the subjects spent working on a computer was 5 hours per week with a range of 0 to 40 hours per week. Fifteen of the subjects played some type of musical instrument including guitar, violin, clarinet, flute, piano, and drums. The subjects participated in sporting activities an average of 5 hours per week with a range of 0 to 30 hours.

When asked to describe their general health, 46 of the subjects reported being in excellent/good health and 9 of the subjects reported fair health. None of the subjects reported having a history of neuropathic disease, renal disease, peripheral vascular disease, thyroid disease, or diabetes. Two subjects reported a history of having arthritis. Fifteen of the subjects responded positively to having a problem with their head, neck, or upper extremities during the previous 6 months prior to data collection. All other subjects denied having any musculoskeletal problems in the past 6 months.

The following information was received in response to specific questions about current pain or symptoms in the neck or upper extremity: dull, aching neck pain and in the C7-T1 dermatomes (subject 8); cramps in the left hand (subject 26); dull, achy pain in the left D3-D4 fingers (subject 37); and numbness and tingling in both hands (subject 46).

A review of the subjects' histories revealed that subjects 8, 37, and 46 had subjective complaints suggestive of median or ulnar dysfunction. Otherwise, there were no indicators in the information obtained in the history suggesting median or ulnar nerve abnormalities in the upper extremities of these dental assistants.

Screening Examination

Active Range of Motion: Two subjects had limited active range of motion (AROM). One had limited right shoulder internal rotation and one had limited right elbow extension and forearm supination. All other subjects had normal AROM of the cervical spine, shoulder, elbow, wrist, and hands bilaterally. Cervical quadrant tests were determined to be normal without radicular symptoms in either upper extremity.

Motor Strength: All subjects were assessed to have normal (5/5) muscle strength for the neck flexors, extensors, and rotators (C1-5); both upper extremities to include the scapula elevators, depressors, protractors, and retractors (C1-5); shoulder flexors, abductors, and external/internal rotators (C5-6); elbow flexors and extensors (C5-8); wrist flexors and extensors (C6-8); finger flexors and extensors (C7-T1); and hand intrinsics (C8-T1). All upper extremity peripheral nerves (motor components) and myotomes (C4-T1) were assessed during motor testing.

Sensation: Five subjects had abnormal sensation to light touch. Sixteen subjects had abnormal palm to tip light touch sensation. Eight subjects had abnormal vibration sensation (3 metacarpal, 3 thumb, 1 long finger, 1 little finger). Of the subjects with abnormal sensation, only 3 subjects had abnormal median nerve findings on electrophysiological testing (subject 37, light touch and pain; subject 49, palm to tip light touch; subject 20, abnormal vibration test). Otherwise, all subjects had normal peripheral nerves (sensory components) and C4-T1 dermatome sensory testing results for light touch, pain/pin prick, and vibration in both upper extremities.

Muscle Stretch Reflexes (MSRs) and Pathological Signs: Two subjects had absent MSRs. One subject had absent brachioradialis (C6) MSRs bilaterally, and a second subject had an absent left brachioradialis (C6) MSR. Otherwise, all subjects displayed present and equal muscle stretch reflexes. Pathological signs (Hoffman) were absent in both upper extremities of all subjects.

Special Tests: Twelve subjects had positive Tinel's tests (3 median nerve at the wrist; 1 ulnar nerve at the wrist; 8 ulnar nerve at the elbow). Only one subject (No. 26) had a positive Tinel's sign of the median nerve at the wrist and abnormal electrophysiological findings in the median nerve. Three subjects had positive Phalen's test for the median nerve. One subject had a positive EHFT. None of the subjects with a positive Phalen's test for the median nerve or EHFT for the ulnar nerve had abnormal electrophysiologic findings on NCS testing. Twenty subjects had positive ULNDTs for the median nerve. Only subject 37 had a positive ULNDT for the median nerve and abnormal electrophysiologic findings on NCS testing. Forty-two subjects (76.1%) had wrist ratios (WR) $\geq$0.70. Four subjects (8, 20, 26, 37) with abnormal WR also had abnormal median nerve electrophysiological findings.

Thoracic Outlet Tests: All subjects displayed normal radial pulses when the upper extremities were tested in the 3 thoracic outlet syndrome testing positions.[19,20]

Other than 5 subjects (8, 20, 26, 37, 49) who had abnormal findings on physical examination and abnormal median nerve electrophysiologic testing, there were no diagnostic indicators or evidence of median and ulnar nerve abnormalities in either upper extremity of the dental assistants tested during the physical examination portion of the assessment.

Table 1. Mean, standard deviation, and range of values for neural conduction measurements.

	Right Upper Extremity			Left Upper Extremity			Normal Values
Median Nerve	Mean	SD	Range	Mean	SD	Range	
Motor							
DML (milliseconds)	3.5	0.4	2.8-4.6	3.5	0.5	2.7-5.5	<4.2
Amp CMAP (mV)	9.0	2.2	5-16	8.7	2.9	5.0-17	>5
MNCV BE - W(m/sec)	59	4.1	50-67	59	4.1	51-67	>50
Sensory							
Palmar DSL (ms)	1.9	0.2	1.6-2.4	1.9	0.2	1.5-2.9	<2.2
Palmar Amp SNAP (μV)	117	41.9	20-200	103	41.8	23-200	>15
2 Digit DSL (milliseconds)	3.0	0.2	2.5-3.6	2.9	0.3	2.5-4.0	<3.5
2 Digit Amp SNAP (μV)	31	12	15-66	28	10.5	16-55	>15
Ulnar Nerve							
Motor							
DML (milliseconds)	2.8	0.3	2.2-3.4	2.8	0.3	2.3-3.3	<3.6
Amp CMAP (mV)	9	2.5	5-17	8	2.3	5-14	>5
MNCV BE - W (m/sec)	64	4.1	54-73	62	4.4	51-74	>50
MNCV AE - BE (m/sec)	67	5.6	54-77	65	6.2	52-76	>50
Sensory							
Palmar DSL (milliseconds)	1.7	0.1	1.5-2.1	1.7	0.1	1.5-2.1	<2.2
Palmar Amp SNAP (μV)	44	27.0	15-153	48	26.8	16-130	>10
5 Digit DSL (milliseconds)	2.8	0.2	2.5-3.5	2.9	0.2	2.5-3.2	<3.5
5 Digit Amp SNAP (μV)	23	6.8	14-52	26	10.8	12-79	>10

Glossary
AE – above elbow
Amp – amplitude
BE – below elbow
CMAP – compound motor action potential
DML – distal motor latency
DSL – distal sensory latency
MNCV – motor nerve conduction velocity
SNAP – sensory nerve action potential
W – wrist

Nerve Conduction Studies

The results of the nerve conduction studies are presented in Table 1. The values for these electrophysiological variables for each subject were compared to a chart of normal values (Table 1). This chart of normal values was developed in the Clinical Electrophysiological Laboratory of Texas Physical Therapy Specialists (New Braunfels, Texas), and revalidated at the Electrophysiological Laboratory, Army-Baylor University Doctoral Program in Physical Therapy. The chart of normal values depicted in Table 1 is similar to other charts of normal values.[27-30]

A comparison of the results of the study with the chart of normal values determined that 4 subjects (8, 20, 37, 46) had electrophysiologic evidence of median mononeuropathy at or distal to the wrist (Table 2).

Interestingly, when comparison studies between the median and ulnar palmar DSLs, digital DSLs, and DMLs in the same and opposite extremities, and the digit 4 median/ulnar comparison study in the same extremity were assessed, electrodiagnostic abnormalities of the median nerve at or distal to the wrist in an additional 2 subjects (26, 49) were revealed (Table 2).

Six of the 55 subjects (11%) presented with abnormal electrophysiologic values suggestive of median mononeuropathy at or distal to the wrist. Five of the subjects had abnormal electrophysiologic values in both hands. Three of the subjects (8, 20, 37) had electrophysiologic abnormalities of both the motor and sensory fibers , and three (26, 46, 49) had abnormal findings in only the sensory fibers (Table 2). Five of the 6 subjects had clinical examination findings consistent with the electrophysiological findings. (Tables 3 and 4) The ulnar nerve electrophysiologic assessment was normal in all subjects.

COMMENT

To our knowledge, no studies have used histories, physical examinations, and NCS to assess the status of the median and ulnar nerves in Soldiers enrolled in a dental assistant course. A thorough history and physical examination are considered essential screening tools for detecting signs and symptoms of peripheral neuropathy.[28-30,32-34] Nerve conduction measurement is often performed on the median and ulnar nerves to determine whether certain entrapment neuropathies are present.[28-42] Nerve conduction measurement is considered the gold standard when assessing the electrophysiologic status of the peripheral nerve.[28-42]

Of the 55 Soldiers in the dental assistant course that participated in the study, 11 hands (10%) in 6 subjects (11%) had electrodiagnostic abnormalities of the median nerve at or distal to the wrist. Subject 8 was an 18-year-old right hand dominant (RHD) male who worked in

the fast food industry prior to joining the military. He regularly played the guitar 12 hours/week and worked on the computer for 21 hours/week. The subject complained of a dull, aching pain in the bilateral C7-T1 dermatome but had no other symptoms suggestive of median mononeuropathy at or distal to the wrist. Physical examination determined that the patient's bilateral wrist ratios were >0.70, but otherwise there were no findings on the physical examination suggestive of a median mononeuropathy. During NCS testing, subject 8 had bilateral median mononeuropathy at or distal to the wrist that affected both the motor and sensory fibers.

Subject 20 was a 45-year-old RHD male who had been a mail carrier before entering the military and had been worked in the military for 8 years prior to the dental assistant course as an infantryman, mechanic, and vehicle operator. He had no symptoms including pain, numbness/tingling, or weakness in bilateral upper extremities (BUE). However on physical examination, the subject displayed an abnormal left wrist ratio (>0.70), decreased vibration sensation on the right metacarpal area, and decreased vibration sensation on the left D1-D2-D3. He had bilateral median mononeuropathy at or distal to the wrist affecting both motor and sensory fibers on the left and motor fibers only on the right.

Table 2. Subjects with positive findings on neural conduction comparison studies.

		Palmar DSL*			Digital DSL*		
Subject	Hand	Median	Ulnar	Difference	Median	Ulnar	Difference
8	R	2.3	1.7	0.6	3.4	2.9	0.5
	L	2.3	1.7	0.6	3.4	3.0	0.4
20	R	2.2	1.6	0.6	3.2	2.7	0.5
	L	2.3	1.7	0.6	3.4	2.8	0.6
26	R	2.2	1.6	0.6	3.4	2.8	0.6
	L	1.9	1.6	0.3	3.1	2.8	0.3
37	R	2.4	1.9	0.5	3.5	2.9	0.6
	L	2.9	1.8	1.1	4.0	2.9	1.1
46	R	2.4	1.6	0.8	3.6	2.9	0.7
	L	2.2	1.8	0.4	3.3	2.7	0.6
49	R	2.1	1.6	0.5	3.5	2.9	0.6
	L	1.9	1.7	0.2	3.0	3.0	0.0
		DML*			D4 DSL*		
Subject	Hand	Median	Ulnar	Difference	Median	Ulnar	Difference
8	R	4.6	2.8	1.8	3.6	2.8	0.8
	L	4.5	2.9	1.6	3.4	3.3	0.1
20	R	4.3	2.7	1.6	3.3	2.9	0.4
	L	4.3	2.7	1.6	3.6	2.6	1.0
26	R	3.7	2.7	1.0	3.3	2.8	0.5
	L	3.5	2.9	0.6	3.4	2.7	0.7
37	R	4.3	2.8	1.5	3.6	3.1	0.5
	L	5.5	2.9	2.6	4.3	3.1	1.2
46	R	4.2	2.6	1.6	3.6	2.9	0.7
	L	3.8	2.6	1.2	3.5	2.7	0.8
49	R	4.2	2.5	1.7	3.3	2.9	0.4
	L	3.6	2.6	1.0	3.0	2.8	0.2

*All units are milliseconds.

DSL indicates distal sensory latency. DML indicates distal motor latency.

Notes:

Prolonged DSL (palmar and digit) difference ≥0.6 (normal ≤0.5)
Prolonged D4 median/ulnar difference ≥0.7 (normal ≤0.6)
Prolonged median D2 DSL ≥3.7 (normal ≤3.6)
Prolonged DML difference ≥1.1 (normal ≤1.0)
Prolonged median palmar DSL ≥2.3 (normal ≤2.2)
Prolonged DML ≥4.3 (normal ≤4.2)

Subject 26 was a 21-year-old left hand dominant (LHD) female who had a 3-month history of bilateral hand cramping and a family history of arthritis and CTS. The subject did not list any previous occupations before entering the military 3 months prior to the testing session. Physical examination determined that this subject had an abnormal bilateral wrist ratio (>0.70), and a positive Tinel's sign over the right median nerve at the wrist. The subject had early bilateral median mononeuropathy at or distal to the wrist of the sensory fibers based on comparison studies. Subject 26 also had a positive Tinel's sign of the right ulnar nerve at the wrist, but NCS studies of the right ulnar nerve were normal.

Subject 37 was a 39-year-old LHD male who has been a medic in the Army National Guard for 13 years. Prior to entering the military, subject 37 had been an ambulance and rescue worker. Subject 37 had a 6-month history of a dull, aching pain in the left D3-D4. Physical examination revealed an abnormal bilateral wrist ratio (>0.70), abnormal sensation to light touch and pinprick in the left C6 dermatome, and an abnormal bilateral ULNDT examination. The subject had bilateral median mononeuropathy at or distal to the wrist affecting both motor and sensory fibers. The subject had normal NCS studies of both ulnar nerves.

Subject 46 was a 29-year-old RHD male who had no current symptoms in BUE but stated occasional numbness and tingling in both hands prior to joining the military 6 months before the exam. In civilian life, the subject was an electrician and played the guitar approximately one hour per week. He had no findings on physical examination to suggest a bilateral median mononeuropathy at or

Table 3. Symptoms and history of subjects with electrophysiologic evidence of median mononeuropathy at or distal to the wrist.

Subject (+NCS)	Symptoms	Duration of Symptoms	Patient History
8 (R/L)	Dull, achy pain in C7-T1 dermatome bilaterally	Unknown	Guitar player, worked in fast food industry
20 (R/L)	None	N/A	Mail carrier; previous military: infantry, mechanic, and vehicle operator
26 (R/L)	Cramps in left hand intrinsics	3 months	Family history of CTS and arthritis
37 (R/L)	Dull, achy pain in left middle/ring fingers	6 months	Ambulance and rescue worker
46 (R/L)	No current symptoms; N/T in hands prior to joining military	N/A	Family history of CTS; previous work history as electrician, guitar player
49 (R)	None	N/A	Dental assistant; waiter

NCS indicates nerve conduction studies. CTS indicates carpal tunnel syndrome.

distal to the wrist. Subject 46 had a right median mononeuropathy at or distal to the wrist affecting the sensory fibers (prolonged palmar DSL), and an early left median mononeuropathy affecting the sensory fibers based on comparison studies.

Subject 49 was an 18-year-old RHD female and was the only soldier in the study that had prior experience and work history (2 years) as a civilian dental assistant. She had no symptoms in BUE. On physical examination, she had no findings suggestive of median mononeuropathy, but had abnormal sensation to light touch of the right D5 and a positive Tinel's sign of the right ulnar nerve at the elbow. NCS studies of the right ulnar nerve were normal. On NCS testing, subject 49 had an early right median mononeuropathy at or distal to the wrist affecting only the sensory fibers based on comparison studies.

Four of the 6 subjects with abnormal electrophysiological findings of median mononeuropathy at or distal to the wrist had a wrist ratio ≥0.70. It is important to note that 42 subjects (76%) had an abnormal wrist ratio ≥0.70, but only 3 subjects had clinical electrophysiologic evidence of median mononeuropathy at or distal to the wrist and abnormal wrist ratios. There is growing evidence suggesting that wrist anatomy may predispose individuals to carpal tunnel syndrome.[23-25] Specifically, 3 separate studies have identified that "square-shaped" wrists, or wrists with larger wrist ratio indexes (>0.67-0.70), appear to be predisposed to CTS.[23-25] To obtain the ratio both the anteroposterior (AP) and mediolateral (ML) widths are measured at the distal crease of the wrist. The wrist ratio is then calculated by dividing the AP width by the ML width. A 2005 study revealed that this measure was both reliable and sensitive for determining the presence of electrodiagnostically confirmed CTS.[24] Other than the wrist ratio, there were no other consistent physical exam findings across subjects in this study.

In this population of Soldiers entering the dental assistant training program, 5 of the 6 subjects with electrophysiologic evidence of median mononeuropathy at or distal to the wrist had prior occupations both in the civilian and military workforce. Subject 8 worked in the fast food industry; subject 20 was a mail carrier (civilian) and an infantryman, mechanic, and vehicle operator in the military; subject 37 worked as an ambulance and rescue worker; subject 46 was an electrician; and subject 49 was the only subject in this population with experience as a civilian dental assistant. It appears that these subjects with electrophysiologic evidence of median mononeuropathy at or distal to the wrist may indeed be pre-exposed to disorders that affect people performing intensive work with their hands.[1-3]

Three of the subjects (8, 46, 49) had known risk factors for developing median mononeuropathy at or distal to the wrist. Subject 49 had previous civilian dental experience. Median mononeuropathies at or distal to the wrist have previously been reported in the dental assistant population.[12,13,15,16] Two subjects (8, 46) played musical instruments (guitar), and there is evidence to support that guitarists are susceptible to having median mononeuropathies at or distal to the wrist.[43] It is interesting to note that if we exclude the 3 subjects with known risk

Table 4. Physical examination findings on subjects with electyrophysiologic evidence of median monomeuropathy at or distal to the wrist.

Subject	Dominant Hand	+NCS	Physical Exam Findings
8	R	B	R&L wrist ratio ≥ 0.70
20	R	B	Left wrist ratio ≥ 0.70; right metacarpal abnormal vibration; left metacarpal/thumb/long & little finger abnormal vibration
26	L	B	R&L wrist ratio ≥ 0.70; right abnormal ROM; right Tinel's median nerve at wrist & ulnar nerve at wrist
37	L	B	R&L wrist ratio ≥ 0.70; abnormal sensation left C6 dermatome; R&L ULNDT
46	R	B	no positive findings
49	R	R	Right abnormal palm-to-little-fingertip light touch; right Tinel's ulnar nerve at elbow

NCS indicates nerve conduction studies. R&L indicates right and left. ULNDT indicates upper limb neural dynamic testing.

factors, the prevalence of median mononeuropathy at or distal to the wrist is reduced to 5.45%, which is consistent with previous reports on the general population.[44]

In a population such as the Soldiers enrolled in a dental assistant training program that were studied here, it is reasonable to expect that subclinical upper extremity mononeuropathies secondary to repetitive overuse may be present. In the early stages of a mononeuropathy of this type, many individuals with a clinically detectable problem are not aware that their neural function has been impaired.[44] Atroshi et al[44] examined 125 asymptomatic controls with NCS of the median nerves and they reported that 18% (n=23) had electrophysiological evidence of carpal tunnel syndrome.

Atroshi et al[44] stated that the estimation of the prevalence of carpal tunnel syndrome in a general population may contribute to the early diagnosis and effective treatment of subjects and provide useful data for the interpretation of results that estimate the prevalence of carpal tunnel syndrome in specific occupational groups. Franzblau and Werner[45-47] further suggest that performing NCS on individuals without symptoms of carpal tunnel syndrome is important because it permits the assessment of the overall relationship between the electrophysiological properties of the nerve and other clinical features of carpal tunnel syndrome. Although no strong evidence exists regarding the prevention or progression of CTS, it makes sense, theoretically, to identify a problem early, where a minor intervention, such as a resting night splint or ergonomic changes in the work environment, might rectify the dysfunction.[45-47]

A valuable extension of this study would be evaluation of these dental assistants as they progress through their dental health careers and to reevaluate these dental assistants in 5 to 10 years to determine whether these individuals who presented with early electrodiagnostic abnormalities of median nerve at or distal to the wrist later develop symptomatic carpal tunnel syndrome. Future research should include the development of more accurate diagnostic tests performed during the physical examination to determine the presence of median mononeuropathy at or distal to the wrist. Since the majority of current evidence is based on individuals already being symptomatic, a larger study of the general population would be required to more accurately determine prevalence. Last, a longitudinal study should be conducted to determine if there is a relationship of physical examination findings as predictors for development of CTS. This could be developed into an occupational screening tool that would identify individuals at greater risk. Additional long-term prospective studies examining the prevalence and prevention of upper extremity disorders, to include carpal tunnel, appear to warrant further investigation.

CONCLUSION

This descriptive study examined a sample of 55 US Army Soldiers who were enrolled in a training program to become dental assistants for the presence of median and ulnar neuropathies. Six of the 55 subjects (11%) presented with abnormal electrophysiologic values suggestive of median mononeuropathy at or distal to the wrist. Five of the subjects had abnormal electrophysiologic values in both hands. Five of these 6 subjects had clinical examination findings consistent with the electrophysiological findings. The ulnar nerve electrophysiologic assessment was normal in all subjects sampled.

The prevalence of median mononeuropathies in this sample of Soldiers at the onset of training to become dental assistants is greater than 5% prevalence reported in previous healthy populations and is less than 26% prevalence in previous research examining Army dental assistants with dental work experience. These findings suggest that nerve conduction comparison studies may provide sensitive measures and early indicators for detecting early median nerve compromise at or distal to the wrist. Additional prospective research is required to validate our findings and determine the factors that are predictive of activity limitations and participation restrictions in dental assistants who develop carpal tunnel syndrome.

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REFERENCES

1. Franklin GM, Haug J, Heyer N, Checkoway H, Peck N. Occupational carpal tunnel syndrome in Washington State, 1984-1988. *Am J Public Health*. 1991;81(6):741-746.
2. Hanrahan LP, Higgins D, Anderson H, Haskins L, Tai S. Project SENSOR: Wisconsin surveillance of occupational carpal tunnel syndrome. *Wis Med J*. 1991;90(2):80, 82-83.
3. Stockstill JW, Harn SD, Strickland D, Hruska R. Prevalence of upper extremity neuropathy in a clinical dentist population. *JADA*. 1993;124(8):67-72.
4. Anton D, Rosecrance J, Melino L, Cook T. Prevalence of musculoskeletal symptoms and carpal tunnel syndrome among dental hygienists. *Am J Ind Med*. 2002;42(3):248-257.
5. Conrad JC, Conrad KJ, Osborn JB. A short-term, three-year epidemiological study of median nerve sensitivity in practicing dental hygienists. *J Dent Hyg*. 1993;67(5):268-272.
6. Corks I. Occupational health hazards in dentistry: musculoskeletal disorders. *Ont Dent*. 1997;74(6):27-30.
7. Guay AH. Commentary: ergonomically related disorders in dental practice. *JADA*. 1998;129(2):184-186.
8. Osborn JB, Newell KJ, Rudney JD, Stoltenberg JL. Carpal tunnel syndrome among Minnesota dental hygienists. *J Dent Hyg*. 1990;64(2):79-85.
9. Werner RA, Hamann C, Franzblau A, Rodgers PA. Prevalence of carpal tunnel syndrome and upper extremity tendinitis among dental hygenists. *J Dent Hyg*. 2002;76(2):126-132.
10. Cherniack M, Brammar AJ, Nilsson T, Lundstrom R, Meyer JD, Morse T. Nerve conduction and sensorineural function in dental hygienists using high frequency ultrasound handpieces. *Am J Ind Med*. 2006;49(5):313-326.
11. Lalumandier JA, McPhee SD. Prevalence and risk factors of hand problems and carpal tunnel syndrome among dental hygienists. *J Dent Hyg*. 2001;75(2):130-134.
12. Lalumandier JA, McPhee SD, Riddle S, Shulman JD, Daigle WW. Carpal tunnel syndrome: effect on Army dental personnel. *Mil Med*. 2000;165(5):372-378.
13. Rice VJ, Nindl B, Tentikis JS. Dental workers, musculoskeletal cumulative trauma, and carpal tunnel syndrome. Who is at risk? A pilot study. *Int J Occup Saf Ergon*. 1996;2(3):218-233.
14. Macdonald G, Robertson MM, Erickson JA. Carpal tunnel syndrome among California dental hygienists. *Dent Hyg*. 1988;62:322-327.
15. Greathouse DG, Root RM, Carrillo CR, Jordan CL, Pickens BB, Sutlive TG, Shaffer SW, Moore JS. Clinical and electrodiagnostic abnormalities of the median nerve in dental assistants. *J Orthop Sports Phys Ther*. 2009;39(9):693-701
16. Greathouse DG, Root RM, Carrillo CR, Jordan CL, Pickens BB, Sutlive TG, Shaffer SW, Moore JS. Clinical and electrodiagnostic abnormalities of the median nerve in dental assistants before and after training as preventive dental assistants. *Army Med Dept J*. 2011; January-March 2011:70-81.
17. Werner RA, Armstrong TJ. Carpal tunnel syndrome: ergonomic risk factors and intracarpal canal pressure. *Phys Med Rehabil Clin N Am*. 1997;8(3):555-569.
18. Bramson JB, Smith S, Romagnoli G. Evaluating dental office ergonomics: risk factors and hazards. *JADA*. 1998;129(2):174-183.
19. Dutton M. *Orthopaedic Examination, Evaluation, & Intervention*. New York, NY: McGraw-Hill Medical Publishing Division; 2005.
20. 20. Magee DJ. *Orthopaedic Physical Assessment*. Philadelphia, PA: W.B. Saunders; 1992.
21. Novak CB, Lee GW, Mackinnon SE, Lay L. Provocative testing for cubital tunnel syndrome. *J Hand Surg Am*. 1994;19:817-820.
22. Wainner RS, Fritz JM, Irrgang JJ, Boninger ML, Delitto A, Allison S. Reliability and diagnostic accuracy of the clinical examination and patient self-report measures for cervical radiculopathy. *Spine*. 2003;28(1):52-62.
23. Moghtaderi A, Izadi S, Sharaafadinzadeh N. An evaluation of gender, body mass index, wrist circumference ratio as independent factors for carpal tunnel syndrome. *Acta Neurol Scand*. 2005;112:375-379
24. Wainner RS, Fritz JM, Irrgang JJ, Delitto A, Allison S, Boninger ML. Development of a clinical prediction rule for the diagnosis of carpal tunnel syndrome. *Arch Phys Med Rehabil*. 2005;86(4):609-618.
25. Johnson EW, Gatens T, Poindexter D, Bowers D. Wrist dimensions: correlation with median sensory latencies. *Arch Phys Med Rehabil*. 1983;64:556-557
26. Harkins G, Jayne D, Masullo L, Norton K, Underwood F, Greathouse D. Effects of gender and handedness on neural conductions in humans. *J Clin Electrophysiol*. 1989;1:10-13.
27. American Association of Electrodiagnostic Medicine: Practice parameter for electrodiagnostic studies in carpal tunnel syndrome: summary statement. *Muscle Nerve*. 1993;16:1390-1391.

28. Dumitru D, Amato A, Zwarts M. *Electrodiagnostic Medicine*. 2nd ed. St. Louis, MO: Hanley & Belfus; 2002.

29. Kimura J. *Electrodiagnosis in Diseases of Nerve and Muscle: Principles and Practice*. 3rd ed. New York, NY: Oxford University Press; 2001.

30. Oh SJ. *Clinical Electromyography in Nerve Conduction Studies*. Baltimore, MD: Williams & Wilkins; 1993.

31. Johnson EW, Kukla RD, Wongsam PE, Piedmont A. Sensory latencies to the ring finger: normal values and relation to carpal tunnel syndrome. *Arch Phys Med Rehabil*. 1981;62:206-208.

32. van Dijk JG. Multiple tests and diagnostic validity. *Muscle Nerve*. 1995;18:353-355.

33. MacDermid JC, Doherty T. Clinical and electrodiagnostic testing of carpal tunnel syndrome: a narrative review. *J Orthop Sports Phys Ther*. 2004;34:565-588.

34. Graham B. The value added by electrodiagnostic testing in the diagnosis of carpal tunnel syndrome. *J Bone Joint Surg Am*. 2008;90:2587-2593.

35. Jablecki CK, Andary MT, So YT, Wilkins DE, Williams FH. Literature review of the usefulness of nerve conduction studies and electromyography for the evaluation of patients with carpal tunnel syndrome. AAEM Quality Assurance Committee. *Muscle Nerve*. 1993;16(12):1392-1414.

36. Jablecki CK, Andary MT, Floeter MK, Miller RG, Quartly CA, Vennix MJ, et al. Practice parameter: electrodiagnostic studies in carpal tunnel syndrome. Report of the American Association of Electrodiagnostic Medicine, American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation. *Neurology*. 2002;58:1589-1592.

37. Jackson DA, Clifford JC. Electrodiagnosis of mild carpal tunnel syndrome. *Arch Phys Med Rehabil*. 1989;70(3):199-204

38. MacDermid JC, Wessel J. Clinical diagnosis of carpal tunnel syndrome. A systematic review. *J Hand Ther*. 2004;17:309-319.

39. Melvin JL, Schuchmann JA, Lanese RR. Diagnostic specificity of motor and sensory nerve conduction variables in the carpal tunnel syndrome. *Arch Phys Med Rehabil*. 1973;54:69-74.

40. Moore J. Carpal tunnel syndrome. *Occup Med*. 1992;7(4):741-763.

41. National Institute of Occupational Safety and Health. Carpal tunnel syndrome. In: Bernard BP, ed. *Musculoskeletal disorders and workplace factors*. Washington, DC: US Department of Health and Human Services; 1997:1-29. DHHS publication 97-144.

42. Redmond MD, Rivner MH. False positive electrodiagnostic tests in carpal tunnel syndrome. *Muscle Nerve*. 1988;11(5):511-518.

43. Kennedy RH, Hutcherson KJ, Kain JB, Phillips AL, Halle JS, Greathouse DG. Median and ulnar neuropathies in university guitarists. *J Orthop Sports Phys Ther*. 2006;36:101-111.

44. Atroshi I, Gummesson C, Johnsson R, Ornstein E, Ranstam J, Rosen I. Prevalence of carpal tunnel syndrome in a general population. *JAMA*. 1999;292(2):153-158.

45. Franzblau A, Werner RA, Valle J, Johnston E. Workplace surveillance for carpal tunnel syndrome. *J Occup Rehabil*. 1993;3(1):1-14.

46. Franzblau A, Werner RA, Albers JW, Grant CL, Olinski D, Johnston E. Workplace surveillance for carpal tunnel syndrome using hand diagrams. *J Occup Rehabil*. 1994;4(4):185-198. Available at: http://hdl.handle.net/2027.42/45021. Accessed March 1, 2012.

47. Franzblau A, Werner RA. What is carpal tunnel syndrome? *JAMA*. 1999;282:186-187.

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Erratum

In the article "Reliability of Lower Quarter Physical Performance Measure in Healthy Service Members" published on pages 37-49 of the July-September 2011 issue of the *AMEDD Journal*, the byline entry "John C. Childs" is incorrect. The correct byline entry is "John D. Childs."