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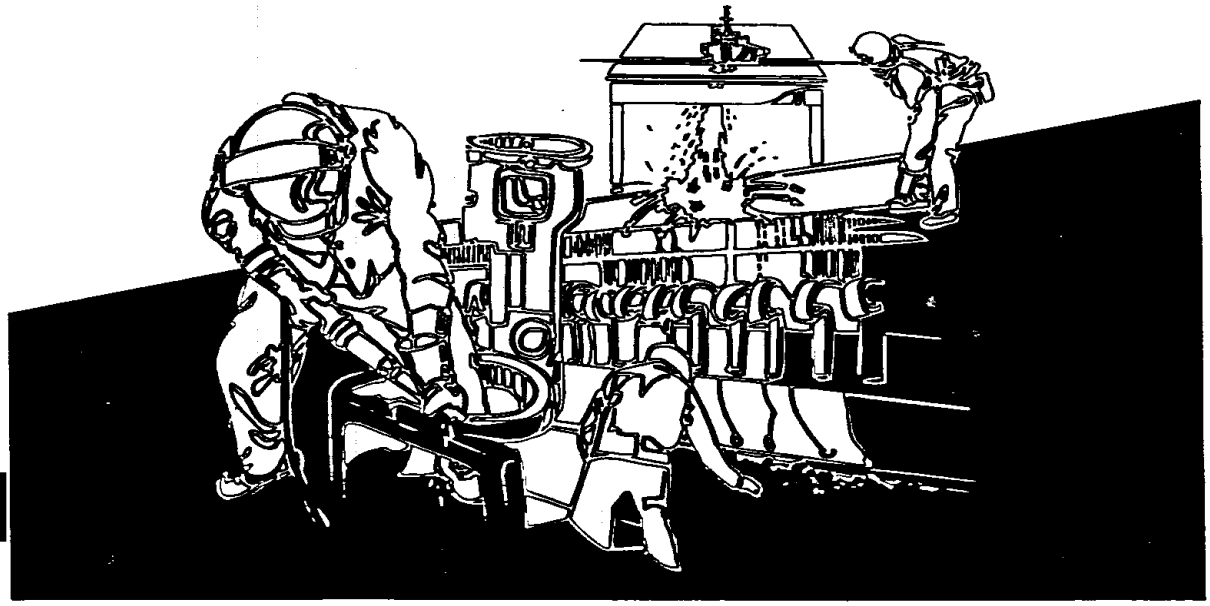
NIOSH

HEALTH HAZARD EVALUATION REPORT

HETA 90-273-2130
FL THORPE & CO., INC.
DEADWOOD, SOUTH DAKOTA



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

CDC
CENTERS FOR DISEASE CONTROL

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 90-273-2130
AUGUST 1991
FL THORPE & CO., INC.
DEADWOOD, SOUTH DAKOTA

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I. SUMMARY

On May 15, 1990 the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from FL Thorpe & Co. to evaluate upper extremity (UE) musculoskeletal (M/S) disorders among their employees.

On December 1 & 2, 1990 NIOSH investigators conducted a site-visit of the facility. The objectives of this evaluation were to 1) determine the prevalence of UE M/S disorders among production employees, 2) describe the medical management of employees with UE M/S disorders, 3) identify jobs with known ergonomic risk factors for developing UE M/S disorders, and 4) outline an ergonomics program with specific recommendations to eliminate the ergonomic hazards.

Work activities within all 10 departments were videotaped for ergonomic evaluation, and all production employees completed a questionnaire designed to gather information on UE M/S symptoms. All employees having carpal tunnel release surgery since 1988 were interviewed, and their medical records were reviewed.

Seventy-six of 94 employees (81%) reported UE M/S symptoms. Sixty-two (66%) reported work-related UE M/S symptoms, and forty-six (49%) reported symptoms consistent with work-related UE M/S disorders. Neck symptoms were reported most frequently (60%), but the hand/wrist area contained the most reported work-related M/S symptoms (46%) and the most reported work-related M/S disorders (35%). The bright cut, wriggle, and wax departments had the highest prevalence of employees with UE M/S disorders.

Nine of the 62 employees (15%) with work-related UE symptoms were evaluated by health care professionals. Of the 46 employees with work-relate UE M/S disorders, three (7%) were given time off work to allow their condition to heal, and two (4%) were assigned a light or restricted duty job.

In 1989 and 1990, seven employees were diagnosed with carpal tunnel syndrome by the local physicians. All of the nerve conduction studies were performed using a hand-held electroneurometer rather than conventional equipment. The electroneurometer results showed right median nerve slowing in 3 of the 7 wrists, and left median nerve slowing in 2 of the 7 wrists. Six carpal tunnel release operations were performed on the right wrist; 4 were done on the left wrist. One employee was given restricted or light duty prior to the carpal tunnel surgery. No employees were given time off work prior to surgery. All employees received at least 5 weeks off work to recover from their carpal tunnel release surgery.

The videotape analysis of the work activities found posture, force, and static muscle contraction hazards present in most jobs. In addition, employees in two jobs were exposed to hand/wrist vibration. All workstation chairs and tables were not adjustable to accommodate the various sizes and shapes of employees. The jobs presenting the strongest association with work-related UE M/S disorders and the highest levels or ergonomic stress include bright cut, wriggle, grind/polish, solder, and repair & design.

Our evaluation found a high prevalence of symptoms consistent with work-related UE M/S disorders among employees in the wax, bright cut, and wriggle departments. These are the same jobs where many ergonomic risk factors were identified. Access to health care providers for employees with UE M/S disorders was limited, and conservative medical treatment was not given an adequate opportunity for success prior to carpal tunnel release surgery.

On the basis of this evaluation, NIOSH investigators concluded that an upper extremity musculoskeletal hazard existed at this plant. Recommendations for a ergonomics program, including specific engineering interventions, are contained in Section VIII of this report.

KEY WORDS: SIC 3911 (Precious Metal Jewelry Manufacturing), ergonomics, vibration, force, repetition, musculoskeletal disorders, cumulative trauma disorders, carpal tunnel syndrome, tendinitis, tenosynovitis, carpal tunnel release surgery.

II. INTRODUCTION

On May 15, 1990 the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from FL Thorpe & Co. to evaluate upper extremity (UE) musculoskeletal (M/S) disorders among their employees. On December 1-2, 1990 NIOSH employees conducted an evaluation of the facility and collected the information contained in this report. The objectives of this evaluation were to:

1. Determine the prevalence of UE M/S disorders among production employees.

2. Describe the medical management of employees with UE M/S disorders.

3. Identify jobs with known ergonomic risk factors for developing UE M/S disorders.

4. Outline a model ergonomic program with specific engineering recommendations to eliminate the ergonomic hazards.

III. BACKGROUND

A. Musculoskeletal Disorders

Musculoskeletal (M/S) disorders is a collective term for a set of specific diagnoses of the musculoskeletal system. The specific diagnoses involve damage to the tendons, tendon sheaths, ligaments, muscles, joints, blood vessels, and peripheral nerves.[1-3] (Table 1) These disorders develop from chronic exposure of a particular body part to repeated biomechanical stress: repetition, force, vibration, extreme angles, or direct trauma.[3-12] Production employees within the jewelry manufacturing industry are exposed to many of these biomechanical stresses while performing their job tasks. In 1989, the Bureau of Labor Statistics estimated 70-150 cases of "disorders due to repeated trauma" occurred in the Precious Metal Jewelry Manufacturing Industry (SIC code 3911), for an incidence rate of 31.6 cases per 10,000 full-time workers.[13]

B. Plant and Process Description

FL Thorpe & Co. manufactures gold jewelry for wholesale and retail distribution. The company has been in operation since 1878, with its new building becoming operational in January 1990. Despite the new building, workstations have not undergone major changes in the past 10 years. At the time of this evaluation the facility employed 115 people, 105 of whom were production employees. The production workers design, cast, stamp, solder, plate, wax,

wriggle, bright cut, repair, package, and ship the jewelry. The workforce is relatively stable, with an approximate 5% turnover per year. Production jobs within the plant are briefly described below.

1. Casting Department - Eight Employees

   There are eight employees performing two jobs. Seated at a workstation, employees insert wax into wooden jewelry molds and, after the wax has solidified, remove the cast from the mold. At a standing workstation, employees hang the wax casts onto a tree-shaped frame and place the frame into plaster of paris.

2. Stamping Department - One Employee

   One employee stamps artistic pieces from thin sheets of gold using a press. The operator applies a kicking motion against a foot-pedal. The operator places and holds the gold sheet inside the press throughout the stamping process.

3. Soldering Department - Thirty Employees

   The majority of the employees in this department solder the decorative gold leaves from the stamping process to rings using compressed air and gas torches. Two tacking stations are also used to join smaller pieces of metal together with a small spot welding machine.

4. Grinding & Polishing Department - Twelve Employees

   Seated at workstations, workers use mechanically driven, rotating buffing and grinding wheels to polish the inner and outer surfaces of rings.

5. Plating Department - Two Employees

   Seated at a workstation, employees briefly (less than 5 seconds) grind and buff jewelry pieces to remove oxidants before plating. Employees then immerse rings and other small pieces of jewelry in a gold plating bath at a standing workstation.

6. Waxing Department - Two Employees

   To provide the wriggling and bright cutting departments with a "workable" piece of jewelry, the waxing department mounts the jewelry onto wooden posts using wax to hold the jewelry in place.

7. Wriggling Department - Sixteen Employees

   Employees remove excess gold from rings and flats using a linear actuator mounted on top of the work surface. The seated employee holds the work piece against a small vibrating blade to chip away gold from the surface.

8. Bright Cutting Department - Ten Employees

   Employees use small hand tools to cut and engrave patterns into the gold surface of various jewelry items.

9. Repair and Design Department - Nine Employees

   Employees mold designs, set stones, and repair jewelry pieces in this department.

10. Packing and Shipping Department - Nine Employees

    Rings, necklaces, and other pieces of jewelry undergo a final inspection before being placed in boxes and wrapped for shipping.

11. Supervisors - Four Employees

    Supervisors are high-seniority employees, trained in all departments, who can fill in for employee shortages in any department. In addition to production line work, they also perform quality control inspections for the various departments.

IV. METHODS

A. Health Outcome Definitions

All production employees working the day of the NIOSH site-visit were asked to complete a questionnaire. The questionnaire was designed to gather demographic and recreational activity information, occupational histories, medical histories, and information on upper extremity (UE) symptoms (pain, numbness, tingling, aching, stiffness, or burning) experienced within the previous year. If a participant had experienced problems in one or more UE joints, information was sought regarding the problem's frequency, duration, intensity, onset, and the job the employee was assigned when the symptoms began. Employees working at the facility for 1 month or less were excluded.

Three outcomes of interest were identified: UE Musculoskeletal (M/S) Symptoms (Sx), Work-Related (W-R) UE M/S Sx, and symptoms consistent with W-R UE M/S disorders.

1. UE M/S Sx were defined as:
   a. Pain, numbness, tingling, aching, stiffness, or burning experienced within the previous year, and
   b. Involving the neck, shoulder, elbow, or hand-wrist.

2. W-R UE M/S Sx were defined as UE M/S Sx, where
   a. Symptoms began after employment at the plant, and
   b. There were no previous accident or sudden trauma to the joint.

3. W-R UE M/S disorders were defined as W-R UE M/S Sx, where
   a. Symptoms lasted for more than one week, or occurred at least once a month, and
   b. Symptoms were considered moderate, severe, or the worst pain ever experienced.

Prevalence rates by joint areas are reported for the 3 outcome definitions. Job specific W-R UE M/S disorder prevalence rates are reported by employees whose symptoms began on their current job.

To ascertain whether certain demographic factors, medical conditions, or recreational activities were associated with the development of the three outcome definitions, contingency analysis was performed using SAS/PC.[14] Associations are reported as relative risks (RR) with Mantel-Haenszel 95% confidence intervals for the RR, and Student's t-test. Significance was defined as the lower end of the a 95% confidence limit being greater than or equal to one, and a p-value less than or equal to 0.05.

B. Medical Management

To evaluate the medical management of workers with W-R UE M/S disorders the questionnaire contained questions to determine whether 1) employees had seen a health care provider for the condition, 2) employees were assigned to light or restricted duty, and 3) employees had been given time off work to recover from the condition. In addition, the company's workers compensation and OSHA 200 logs were inspected for cases of carpal tunnel syndrome for the years 1988-1990.

C. Ergonomic Exposure Assessment

In most manufacturing operations where items are mass produced, workers are paced by machines and perform a limited number of very repetitive activities. In these environments, repetitiveness is one of the primary risk factors for acquiring hand-wrist cumulative trauma disorders. At FL Thorpe & Co., however, jewelry is custom crafted in relatively small quantities. Many jobs require a

variety of movements using several different tools. Within limits, employees can set their own work pace. Cycle time, defined as the time interval needed to complete all elements of a given task, ranged from 1 to 20 minutes. Therefore, cycle time as defined above, is not an appropriate measure of repetitiveness and not appropriate for an overall assessment of this facility's ergonomic demands.

Jobs in each department were videotaped and reviewed in slow motion by two NIOSH ergonomists to identify biomechanical stressors: manual force, awkward postures, and static muscle contractions. A detailed description of these stressors by job title, and a rationale for eliminating or reducing the stress for each job are contained in the results section (V).

V. RESULTS

A. Health Outcome Information

One-hundred-one of the 105 production employees were working the day of the NIOSH visit. Three of the 4 missing employees were out sick (upper respiratory infections), while the fourth was recovering from carpal tunnel release surgery. All 101 (100%) production line employees completed the questionnaire. The age of employees ranged from 18-64 years (mean 37). Most were white (94%) females (99%), with an average of 5 years experience working for FL Thorpe & Co. Seven employees had been working at Thorpe's for less than 1 month, and these employees were excluded from further analysis, leaving a total of 94 employees.

Seventy-six of 94 employees (81%) reported upper extremity (UE) symptoms. Sixty-two (66%) reported work-related UE symptoms, and forty-six (49%) reported symptoms consistent with UE M/S disorders. The neck was the location with the most frequent M/S symptoms (60%), but the hand/wrist had the most frequently reported work-related UE M/S symptoms and disorders (46% and 35%, respectively) (Table 2). Thirteen employees with W-R hand-wrist M/S disorders reported their hand-wrist symptoms began on another job within the facility. These 13 employees were excluded from the job specific prevalence rates, leaving a total of 81 employees. At least 50% of the employees in the wriggle (6/9), bright cut (6/8), and wax (1/1) departments had symptoms consistent with work-related hand-wrist M/S disorders (Table 3).

There were no significant associations between any of the outcome definitions (UE M/S Sx, W-R UE M/S Sx, and W-R UE M/S disorders) and age, number of months on the current job, number of years employed at Thorpe's, total number of hours spent doing

recreational activities, or medical conditions (diabetes mellitus, rheumatoid arthritis, thyroid disorders, gout, renal failure, oral contraceptive use, or pregnancy). No employees reported systemic lupus erythematosis or alcoholism, therefore statistical calculations could not be performed for these two medical conditions.

B. Medical Management

NIOSH Survey

Nine of the 62 employees (15%) with work-related UE symptoms were evaluated by health care professionals. Three of the 46 (7%) employees with work-related UE M/S disorders were given time off work to allow their condition to heal, while two employees (4%) was assigned to a light or restricted duty job.

OSHA 200 Logs and Workers Compensation Claims

Based on the company's OSHA 200 logs and workers compensation claims for the years 1988-1990, seven employees were diagnosed as having carpal tunnel syndrome (Table 4). They came from the grind (2 employees), bright cut, wriggle, wax, solder, and cast jobs. Onset of symptoms ranged from 1 week to 12 years prior to physician evaluation. All seven of the nerve conduction studies were performed using a hand-held electroneurometer rather than conventional equipment. The electroneurometer results showed right median nerve slowing in 3 of the 7 wrists, and left median nerve slowing in 2 of the 7 wrists. Six carpal tunnel release operations were performed on the right wrist, 4 were performed on the left wrist. Three of the six employees had their operation less than 1 month from the date of diagnosis. One employee was given restricted or light duty prior to their carpal tunnel surgery. No employees were given time off work prior to surgery. Following surgery, all employees were given at least five weeks off work for healing of the median nerve and the surgical wound. Three of the 6 were assigned to light or restricted duty upon return to work. None of the 6 employees were involved in a rehabilitation or work hardening program after their carpal tunnel release surgery.

C. Ergonomic Assessment

1. Casting

Although work in the casting department requires some use of pneumatic and/or small hand tools, there are few high force requirements, or high rates of repetition based on the cycle time defined in the methods section. One source for concern in

this area is the design of the work stations. Workbenches and chairs are not adjustable, and given the marked variation in employee size, the potential exists for static loading of the arm and shoulder muscles. Poor seat posture can lead to fatigue, poor performance and interference with work.[15] Close visual inspection of the workpiece is also required; employees were frequently observed abducting the shoulder to lift the workpiece up to the light for a better view.

The bench used at the standing workstation is also fixed in height, and employees were observed bending over the table with trunk and neck flexed. A pinch grip with total ulnar wrist deviation was used to force the outer portion of the mold over the post.

2. Stamping

This task appears to have potential for inducing significant shoulder, neck, back and leg fatigue. The design of the stamping machine requires the operator to maintain the head and neck in a flexed position to view the operation. The torso is also flexed, the shoulders are abducted, and significant amounts of force are applied with the arms (to hold the workpiece in place) and lower leg (to activate the stamp) during this process. Neither the chair nor the machine can be adjusted to allow the operator to assume a more comfortable working position.

The stamping machine did not appear to have a safety mechanism to prevent the operator from placing his/her fingers in the stamp during operation.

3. Soldering

Ergonomic hazards identified in the soldering department are associated with posture and the force requirements of various manual tasks performed by employees. Because of the depth of the workbench, most work is performed at or slightly below shoulder level, with the arms raised and the neck and trunk maintained in static flexion. Neither chairs nor work benches are adjustable to provide proper back support or an optimal working height for individual employees. The location of the tools (in a pull-out drawer) requires constant movement of the chair from the workbench and increases the reach distance to the worktable. Neither the chair nor the worksurface provides any support for the arms. Although some fixtures are provided

to support the workpiece, most manual tasks involve both hands. Filing tasks require downward applications of force with the wrist deviated from the neutral position. Most hand tools require use of a pinch grip, which is more fatiguing to the hand and less efficient than a power grip. Although the soldering gun is bent to reduce the amount of wrist deviation, operators must accommodate to the height of the worksurface by raising the elbows and bending the wrists. Both hands are used to perform the grinding task - one as a holding fixture for the workpiece, and the other to hold and control the grinder. The grinder's straight-handle design requires the operator to exert force against the workpiece with a bent wrist.

Additional safety hazards were also noted. None of the employees were observed using protective eyewear during the soldering task. The holding fixture for the soldering gun did not appear to be particularly stable; further, the fixture allows operators to grasp the torch above the handle, which could result in burns.

4. Grinding/Polishing

High hand and arm forces, poor hand/wrist postures, static muscle contractures, and vibration exposure are required in this job. Vibration is transmitted to the hand and arm by the grinding wheel throughout most of the workday. Forceful exertions of the fingers and thumb using a pinch grip, and static contractions of the neck and shoulder muscles are required. Most work is performed at or slightly below shoulder level with the wrist extended. Neither chairs nor work benches appear adjustable to provide sufficient back or leg support for employees.

5. Plating

Although some exposure to hand-arm vibration is incurred during the buffing task, and the seated workstation does not appear to be adjustable, neither of the two tasks performed in this department appears to impose undue stress on the musculoskeletal system. In addition, the opportunity to rotate between the two tasks reduces the potential for static muscle fatigue.

6. Waxing

Although waxing is not highly repetitive (cycle time is approximately 1 minute), the waxing process requires the operator to maintain the elbow in a raised position and to

frequently manipulate the holder during the heating process. Force is applied to the holder using the shoulder and wrist in a bent and raised position. Neither armrests nor padded areas on the worksurface are provided to support the elbow or wrist during this task.

The presence of an open flame on top of the work bench may present an additional hazard to the operator.

7. Wriggling

Awkward postures resulting from the location of the wriggling tool on the worksurface, transmission of vibration energy to the fingers and thumb, and a need to grip the workpiece continuously throughout the work period are potential ergonomic hazards. Awkward postures result because the tip of the wriggling tool is positioned at chest height; operators work with arms extended, elbows bent and the neck maintained in static flexion for most of the work day. Neither the chair nor the workbench provide support for the elbows or forearms. Vibration increases the grip force needed to control items held in the hand.

8. Bright Cutting

Tool use and posture are two major sources of biomechanical stress in this department. Bright cutting is a two-handed operation, in which the non-dominant hand is used primarily as a gripping fixture to hold the workpiece steady while force is applied with the cutting tool by the dominant hand. This is a problem because continuous holding or application of force with the hand can result in fatigue and loss of finger flexibility. Forceful and repetitive exertions involving the shoulder were also noted. The cutting tool appears to press into the palm at the base of the thumb. One employee was observed placing a small piece of material on her hand for use as a pad; another employee was observed wearing a workglove on her dominant (cutting) hand. Neither chairs nor work benches provide arm support or adjustment features. In one instance, an operator was observed using the pull-out drawer in the front of the workbench as an armrest. Static neck flexion results from the operator's need to perform detailed operations on the work piece.

9. Repair and Design

Concerns in the repair and design area are similar to those in the bright cutting area. Static neck flexion and shoulder abduction, use of one hand as a static holding device and large applications of force with small hand tools were observed.

10. Packing and Shipping

Many of the ergonomic concerns identified in packing and shipping are linked to workstation design. Packing and shipping involves a number of different activities (e.g., writing, inspecting, wrapping). In some cases, materials to support these tasks (light fixtures and magnifying glasses for inspection) are not provided at the workstation or cannot be easily accessed (e.g., boxes and labels stored on the floor). In these instances, the operator is forced to compensate by assuming unnatural postures (neck and trunk flexion, shoulder abduction and extension). Workstation furniture is not adjustable to provide different workers with a comfortable working posture for the entire work shift. Static neck flexion and shoulder abduction results from working at an inappropriate height. Packing requires prolonged periods of standing and walking, which can result in back and leg fatigue. Anti-fatigue mats are not provided for operators working in the packing area.

Manual force is also a concern due to use of small hand tools. Needle-nose pliers and punch tools (used to insert necklaces and pins into cards) require application of force with the palm of the hand. There is also a risk of traumatic injury (laceration or cut) associated with the use of the punch. Buffing requires repetitive and forceful deviation of the wrist, combined with application of pinch grip forces.

VI. DISCUSSION

An illness is work-related when a) work causes the condition, b) work exposures contribute to the development of the condition, or c) work exacerbates a preexisting condition.[16] This study's work-related case definition required that the symptoms began after employment at the plant and excluded employees with prior injuries (fractures, sprains, etc.) to their upper extremities. The strict criteria for work-relatedness (excluding employees where work exacerbates a preexisting condition) probably resulted in an under-estimation of the true work-related UE CTD prevalence. There were no significant differences between the musculoskeletal outcomes with regard to non-occupational factors (recreational activities, hobbies, and medical conditions reported to be associated with UE CTDs).[17,18]

There are no simple medical tests to diagnose UE M/S disorders, nor is there a universally accepted case definition. This study used symptom frequency, duration, and intensity to distinguish UE M/S disorders from common musculoskeletal symptoms. No physical examination of the upper extremity musculoskeletal system was performed to confirm the presence of UE M/S disorders.

Finally, our measure of force was a visual estimation of the amount of UE effort needed to complete the assigned job task. Quantitative measurements of force require the use of surface electromyography under carefully controlled conditions. These quantitative measures of force were not utilized in this evaluation.

VII. CONCLUSION

Certain departments within this facility were found to have many ergonomic stressors associated with work-related UE musculoskeletal disorders. These departments also had relatively high prevalences of work-related UE M/S disorders. At the time of this evaluation some aspects of an ergonomics program had been initiated, but a comprehensive program had yet to be developed. The following section outlines a model ergonomics program that addresses the principles and specific engineering, administrative, and medical management interventions to prevent or reduce the severity of these disorders.

VIII. RECOMMENDATIONS

A. Engineering

Engineering techniques are the preferred method for prevention of work-related UE musculoskeletal disorders. The focus of engineering controls is to make the job fit the person, not the person fit the job. The engineering recommendations discussed below focus on the workstation, work methods, or tools to reduce biomechanical hazards identified in the results section (V).

1. Casting

Because work at the seated workstations in this department requires only small arm, hand, and finger movements, the task should be located according to its visual requirements. The work surface should be raised, and adjustable chairs should be provided. Features of an "adjustable" chair are as follows:

a) An easily adjusted seat (height and angle of tilt),
b) An easily adjusted backrest (up-down as well as in-out movement) to provide lumbar support,
c) An adjustable footrest to support the underside of the thighs,
d) Adjustable armrests, covered with a soft foam or plastic cushion, located near the front surface of the workplace.

Recommended dimensions for seated workplaces are shown in Figure 1. Additionally, a magnifier should be provided for employees to use while performing close visual work. Worksurfaces should be coated with a matte finish to reduce

glare. Benches and tables should permit work to be done while standing without forward trunk flexion. Figure 2 depicts standing workplace dimensions.

2. Stamping

Redesign of the stamping mechanism is required to reduce the energy demands of this task. The "kicker" should be replaced with a pneumatic (air-driven) stamp, activated by a foot pedal or a two-handed punch button device. A holding fixture or alignment device is needed to hold the work piece in place while the stamp is applied. An adjustable chair with a footrest and adjustable armrests is needed to provide the employee with better postural support. A guard is also needed on the stamping machine to prevent employees from placing their fingers in the stamp during operation.

3. Soldering

Adjustable workstation furniture is needed to provide employees with better back and arm support during extended work periods. Adjustable chairs (Figure 1) or sit-stand chairs which allow variation of the trunk-thigh angle are another alternative. The drawer should be removed from the operator's workbench. Tools should be placed in a rack located within 15" of the front edge of the work surface. Work surface thickness should not exceed 2" to provide sufficient thigh clearance for seated work while maintaining a proper working height (approximately 4" above elbow height). Additional fixtures are needed to hold the workpiece in different orientations for work. The lazy-susan fixture currently in place at the workbench provides the employee with some flexibility for moving the work piece, but to reduce the need to raise the elbow above the shoulder, angle the fixture toward the employee. Bending the handle or tip of the grinder, or providing an angled attachment for the handle would help prevent wrist deviation. A more stable holding fixture for the soldering gun (with guards to prevent the operator from grasping the gun above the handle) is needed to prevent accidental burns. Additional light fixtures and/or magnifying glasses are needed to improve the operator's view of the work piece.

4. Grinding/Polishing

Tools in the grinding area should be modified to allow the employee to perform the task with less force and with the wrist in a more neutral position. If feasible, the grinding machine should be modified to allow set-up of two or more polishing

spindles at the same time (Figure 3). Only one spindle would be engaged by the rotating mechanism in the machine at any time; however, employees could change fixtures quickly and easily for coarser or finer grinding tasks. A fixture for holding the work piece during the grinding process is also needed to eliminate use of static pinch grips and reduce hand-arm vibration exposure. Adjustable workstation furniture is needed to provide the operator with better support for the back and legs during extended work periods (Figure 1). Additional light fixtures and/or magnifying glasses are needed to improve the employee's view of the workpiece.

5. Plating

An adjustable workbench and chair (Figure 1) should be provided to employees in the plating area.

6. Waxing

Adjustable workstation furniture is needed (Figure 1). A sit-stand workstation should be considered because of the downward forces that are exerted with the arm and shoulder. The workbench should be lowered to allow operators to melt and shape wax without raising the elbow above the shoulder. A circular mold, or a fixture which provides both vertical and horizontal working surfaces, would allow the wax to be molded quicker with less force.

7. Wriggling

The tip of the wriggling tool should be lowered to reduce elbow bending and wrist deviation. A magnifying glass mounted on a hinged swivel arm (similar to those used for microelectronics assembly) should be provided to reduce the neck flexion required for viewing the workpiece. Padded armrests on the chair or on the worksurface are needed to support the elbows during this task. Use of a holding fixture to eliminate pinch grip forces and exposure to hand-arm vibration should be investigated.

8. Bright Cutting

If possible, the cutting tool currently used should be replaced with a tool having a powered blade or grooving mechanism. This would reduce the manual force requirements of the task and possibly give the operator more control over the cut. If this is not possible, the tool should be sharpened frequently. The tool handle should be lengthened and padded to reduce pressure

applied to the palm. Gloves may provide some protection for the hands; however, gloves can also reduce tactile sensitivity and may cause employees to grip the tool with more force. The availability of a tool with a curved handle should be investigated; a bent handle may reduce the amount of wrist deviation. A holding fixture mounted on top of the workstation is needed to free the non-dominant hand. Adjustable workstation furniture is needed (Figure 1). Additional light, and a magnifying glass are needed to provide the operator with a better view of the workpiece. The work surface should be covered with a matte finish to reduce glare.

9. Repair and Design

Recommendations for bright cutting are appropriate to the repair and design area. Small cutting tools should be replaced with devices using powered blades or grooving mechanisms. This would reduce the manual force requirements of the task and possibly give the operator more control. Tool handles should be lengthened and padded to reduce pressure on the palm. A holding fixture mounted on top of the workstation is needed to secure the work piece during repair.

Adjustable workstation furniture is needed (Figure 1). Additional light fixtures and a magnifying glass are needed to aid vision during repair.

10. Packing and Shipping

Additional tools or fixtures, adjustable workstation furniture (Figure 1 & 2), and anti-fatigue mats should be used to eliminate or reduce the severity of most musculoskeletal problems in the packing area. Materials such as labels, boxes, and jewelry items should be stored at the workstation within a 15-inch reach of the employee. Adjustable lift tables and tilted storage bins are recommended to provide materials to employees at this distance.

The feasibility of using pre-punched jewelry cards should be investigated. A punch capable of making several holes in one or more cards with a single stamp could be considered. A different pair of pliers with a larger handle is needed to reduce pressure on the palm.

Additional light fixtures and magnifying glasses are needed to reduce neck and trunk flexion and shoulder abduction during inspection (Figure 2). Anti-fatigue mats are needed in packing areas to reduce back and leg fatigue.

B. Administrative

Although we currently recommend training, job rotation, and rest pauses as intuitively reasonable administrative measures to help prevent work-related UE M/S disorders, none of these programs have been validated in a scientific study. Engineering controls are always preferred to administrative controls; administrative controls should only be used 1) as a temporary measure until engineering controls are implemented, or 2) when engineering controls are not technically feasible.

1. Training

The training of new employees should include sufficient time to 1) observe instructors, 2) practice proper craftsmanship, and 3) condition their muscle-tendon groups prior to full capacity work. Conditioning can be accomplished by giving new employees more frequent breaks, shorter working days, or reducing the number of pieces they are expected to complete. This training should be done over the course of several weeks.

2. Job Rotation

The principle of job rotation is to alleviate physical fatigue and stress on a particular set of muscle-tendon-nerve groups by rotating employees between one or two other jobs that use different muscle and tendon groups. Caution must be used in deciding through which jobs employees rotate. Although different jobs may appear to require the use of different muscle-tendon-nerve groups, they may actually pose the same physical demands. Rotation schedules should be designed to ensure that the benefits to some employees are not compromised by subjecting other employees (who must share the ergonomically hazardous tasks) to excessive musculoskeletal stresses.

Following is an example of a rotation schedule. After each break (morning, lunch, and afternoon) rotate the wriggle and grind/polish departments with the solder department; the bright cut department with the cast, plate, and wax departments; the repair and design department with the pack/ship department.

3. Rest Pauses

Rest pauses can relieve fatigued muscle-tendon groups. The length and frequency of these rest pauses depend on the task. Employees within the bright cut, wriggle, wax, and grind/polish departments should be given longer and more frequent breaks than the cast, plate, and pack/ship departments.

C. Medical Management

1. Health Care Providers

Health care providers (physicians or nurses with occupational health training) should be knowledgeable in 1) the prevention, recognition, treatment, and rehabilitation of CTDs; and 2) the basic principles of ergonomics and epidemiology. In addition, they should be familiar with OSHA recordkeeping requirements.

2. Workplace Walk-throughs

Health care providers (HCP) should participate in systematic workplace walk-throughs to understand processes and work practices, identify ergonomic stressors, and maintain close contact with employees. These walk-through surveys should take place every quarter or whenever job tasks change significantly.

3. Upper Extremity (UE) Musculoskeletal (M/S) Disorder Surveillance

The primary purpose of UE M/S disorder surveillance is to identify high-risk jobs for intervention. The information contained in the Results section of this report has accomplished this objective for now. If, however a symptom survey is undertaken as a means of active UE M/S disorder surveillance, the results could be used to 1) monitor the effectiveness of ergonomic interventions; and 2) if conducted in a confidential manner, serve a triage function for employees needing medical evaluations. The symptom survey questionnaire should be short, clear, and use body-part diagrams to identify symptomatic areas (Figure 4). The symptom survey should be anonymous unless the HCP can assure employees of strict confidentiality. If the symptom survey is conducted in an anonymous manner, groups of employees can be identified for medical evaluations.

4. Upper Extremity (UE) Musculoskeletal (M/S) Evaluation

The main objective of UE M/S surveillance is to identify jobs needing intervention to eliminate the ergonomic hazards. The purpose of UE M/S evaluation, on the other hand, is to identify individuals with mild conditions, allowing early treatment to limit the condition's severity.

a. Frequency

The HCP should perform a M/S evaluation of employees assigned to jobs with known ergonomic hazards (all departments except casting and plating). These evaluations

should occur: 1) prior to starting a high risk job (pre-placement or baseline evaluation), 2) following the conditioning period (post-conditioning evaluation), and 3) periodically (approximately every 3 years).

1) Pre-placement or Baseline Evaluation

The purpose of a pre-placement UE M/S evaluation is to establish a base against which changes in an individual's health status can be measured. It should not be used as a pre-employment screening program to preclude certain individuals from employment. Not only might such determinations be discriminatory, but medical screening tests or examinations have not been validated as predictive procedures for determining which workers will develop CTDs.

2) Post-conditioning Period Evaluation

New and transferred employees performing jobs with known ergonomic hazards should be given the opportunity during a 4-6 week break-in period to condition their muscle-tendon groups. This means working at reduced speed with more frequent breaks, a process known as "work hardening." Following this work hardening or conditioning period, the employees should have a medical evaluation to determine if conditioning of the muscle-tendon groups has been successful. Typically, employees report transient soreness or fatigue during the conditioning period, but, these symptoms usually resolve within a few weeks, consistent with normal adaptation to the job. If the symptoms persist, they may represent the early stages of a M/S disorder. Work hardening programs should also be available to employees returning to work from a vacation lasting more than 1-2 weeks. Work hardening programs for these employees can be of a shorter duration.

3) Periodic Evaluation

Employees working on jobs with ergonomic hazards should have a UE M/S evaluation approximately every 3 years. The purpose of this periodic evaluation is to identify employees with UE M/S disorders who, for whatever reason, do not actually report their symptoms to the company's health care provider.

Content

The UE M/S evaluation should consist of a medical and occupational history and a brief non-invasive physical examination (inspection, palpation, range of motion testing, and various maneuvers).

1) Medical and Occupational History

The history should elicit the location, duration, frequency, intensity, and onset of discomfort (pain, swelling, aching, tingling, numbness, burning, or stiffness), and should ascertain whether the symptoms started before or after employment at that facility, if the symptoms are exacerbated by job tasks, if any previous injuries or fractures to that joint area occurred, if any recreational activities or hobbies exacerbate the condition, and if any medical conditions are present which are known to be associated with carpal tunnel syndrome (Table 5).

2) Physical Examination

The upper extremities should be inspected for signs of inflammation (redness, swelling), ganglion cysts, or deformities. Palpation can identify areas of discomfort, detect ganglion cysts, and detect warmth, the third sign of inflammation. Passive, active and resisted range of motion maneuvers can again elicit areas of discomfort in addition to crepitus and stenosis. Other maneuvers include Tinel's test of the median and ulnar nerves, Phalen's test, and Finkelstein's test. Tinel's test of the median nerve consists of tapping the wrist on the area where the median nerve passes through the carpal canal.[20] A positive response (pain, or paresthesia in digits two and three) is suggestive of carpal tunnel syndrome.[21] Tinel's test of the ulnar nerve consists of tapping the wrist on the area where that the nerve passes through Guyon's canal. A positive response (pain or paresthesia in digits 4 or 5) is suggestive of unlar nerve entrapment at the ulnar canal. Phalen's test is flexing both wrists 90 degrees with the dorsal aspect of the hands held in apposition for 60 seconds.[22] A positive response (pain or paresthesia in digits 2 and 3) is suggestive of carpal tunnel syndrome.[21,22] Finkelstein's test is ulnar deviation of the hand with

the thumb flexed against the palm and the fingers flexed over the thumb.[23] A positive response (severe pain at the radial styloid) is due to stretching of the tendons of the abductor pollicis longus and extensor pollicis brevis muscles and is suggestive of DeQuervain's.[23,24] It must be remembered that UE M/S disorders can exist without external manifestations of inflammation.[19]

Collecting and recording this information in a uniform manner is imperative. Figure 5 provides one example of such a recording form.

5. Evaluation of Symptomatic Employees

Individuals presenting to the employee HCP with upper extremity symptoms, or identified as having problems by the confidential symptom survey, should also have a UE M/S evaluation. The content of this evaluation will depend on the intensity and location of the symptoms; however, the physical examination described above (Figure 5) could be used as a framework.

6. Treatment

Having performed the above evaluation, the HCP must now utilize this information to make an assessment and to formulate a treatment plan. Figure 6 provides the HCP with a UE M/S medical management algorithm. This algorithm is not meant to dictate medical practice, but rather to outline a therapeutic approach based on the history and physical examination. The "take-home message" from this algorithm is not its specifics, but rather that 1) symptomatic employees need follow-up to determine the effectiveness of the prescribed treatments, 2) employees with severe symptoms, positive physical findings, or disorders resistant to treatment need further evaluation by an appropriate medical specialist, and 3) conservative therapy deserves an adequate trial before surgical intervention is contemplated.

Conservative therapy involves a) the application of heat or ice, b) non-steroidal anti-inflammatory agents, c) physical therapy, d) splints.

a. Ice or heat application

Ice is used to treat tendon and joint related disorders for pain relief and swelling reduction.[25] Ice decreases the inflammation of M/S disorders even if no external signs of

inflammation are present (redness, swelling, warmth). Heat can be used for muscle related disorders (tension neck syndrome or muscle spasms). Heat is inappropriate for employee's with tendon related disorders, and ice is inappropriate for employee's with vascular related UE M/S disorders.[2]

b. Non-steroidal anti-inflammatory agents (aspirin, ibuprofen, etc.)

These agents are helpful for pain relief, and are probably helpful in reducing soft tissue inflammation, but can have gastrointestinal and renal side effects.[26]

c. Physical therapy

Stretching exercises are an important component of any M/S treatment or rehabilitation program. These exercises should be performed under the supervision of an occupational health nurse (OHN) or physical therapist to assure that the exercises are performed properly and do not aggravate the condition. Once the OHN or physical therapist is convinced that the employee can perform these exercises properly, supervision is needed only intermittently.

In-plant stretching exercises two or three times a day have been suggested as a method of preventing CTDs in asymptomatic employees.[27] We question the effectiveness of such a program for three reasons. One, exercises that involve stressful or extreme range of motions can exacerbate M/S disorders, 2) these exercises typically could reduce the rest periods allowed employees, and 3) a controlled study found these stretching programs to be ineffective.[28]

d. Splints

For hand and wrist M/S disorders we encourage the use of off-the-job or night splints. These splints should maintain the joint in a neutral posture and will discourage employees from performing activities which exacerbate their disorders.[29,30] We do not, however, encourage the use of splints on the job unless the OHN or ergonomist has determined the job does not require wrist bending. The struggle to perform a task requiring wrist deviation with a splint designed to prevent wrist deviation can 1)

exacerbate symptoms in the wrist due to the increased force to overcome the splint, or 2) cause other joint areas (elbows or shoulders) to become symptomatic as the work technique is altered.[2,29]

7. Effectiveness of Treatment

The effectiveness of hot wax treatments and constrictive wrist wraps has not been established. The use of vitamin B-6 to treat or prevent carpal tunnel syndrome has been disproved and may actually be neurotoxic in prescribed doses.31

If initial treatment of the M/S disorder has not resulted in improvement or resolution of the symptoms, the employee should be advised not to continue working at the job causing the problem. He or she can be transferred to a restricted or light duty job, or if such a job is not available, he or she should receive time off work. Only after an adequate trial of conservative therapy and time away from the job causing the problem should surgical intervention be considered. Surgical intervention can be appropriate for carpal tunnel syndrome and trigger finger. While carpal tunnel release surgery has been reported to be 80-90% effective at decreasing or relieving the pain, its effectiveness of returning the employee to his or her original job is 40-50% at best.[32] All employees for whom carpal tunnel release surgery is contemplated should have 1) their treatment program reviewed to assure that conservative therapy has indeed failed, 2) nerve conduction impairment documented by conventional diagnostic equipment, and 3) a second opinion to corroborate the need for surgery.

8. Employee Education

Detection of M/S disorders early in their course prior to the development of a severe, disabling condition should lead to a rapid and complete recovery. To facilitate the early evaluation of M/S symptoms, all employees need to be educated on the causes and the early symptoms and signs of these conditions. Encouraging employees to report symptoms to the HCP allows for timely and appropriate evaluation and treatment. It is important to avoid any potential disincentives for employee reporting, such as limits on the number of visits, monetary bonuses for not reporting to the health unit, requirements to inform supervisors of specific medical findings, or fear of discrimination or reprisal by employers for reporting symptoms. This education process should occur during the orientation or training period and be reinforced periodically.

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Table 1

Specific Diagnoses Referred to as
Cumulative Trauma Disorders (CTDs)

HETA 90-273
FL Thorpe & Co., Deadwood, South Dakota

TENDON RELATED DISORDERS

- Tendinitis
- Tenosynovitis
- Stenosing tenosynovitis of the fingers (Trigger Finger)
- Stenosing tenosynovitis of the thumb (DeQuervain's)
- Peritendinitis (Strain)
- Ganglion cyst
- Lateral epicondylitis (Tennis Elbow)
- Medial epicondylitis (Golfer's Elbow)
- Bicipital tendinitis
- Rotator cuff tendinitis

PERIPHERAL NERVE ENTRAPMENT

- Carpal tunnel syndrome
- Guyon tunnel syndrome
- Radial tunnel syndrome
- Pronator Teres syndrome
- Cubital tunnel syndrome

VASCULAR

- Hand-Arm vibration syndrome
- Ulnar artery thrombosis

NEUROVASCULAR

- Thoracic outlet syndrome

MUSCULAR

- Focal dystonia
- Fibromyositis
- Tension neck syndrome

JOINT/JOINT CAPSULE

- Osteoarthritis
- Bursitis
- Synovitis

Table 2

UE[1] M/S[2] Condition by Joint Area Among 94 Employees
December 1990

HETA 90-273
FL Thorpe & Co., Deadwood, South Dakota

JOB TITLE	UE M/S SX[3] #	(%)	W-R[4] UE M/S SX #	(%)	W-R UE M/S DISORDERS #	(%)
NECK	56	(60%)	36	(38%)	25	(27%)
SHOULDER	36	(38%)	25	(27%)	18	(19%)
ELBOW	24	(26%)	17	(18%)	13	(14%)
HAND/WRIST	54	(57%)	43	(46%)	33	(35%)
ANY UE AREA	76	(81%)	62	(66%)	46	(49%)

1 UE = Upper Extremity
2 M/S = Musculoskeletal
3 SX = Symptoms
4 W-R = Work-Related

Table 3

Work-Related Neck, Shoulder, Elbow, Hand-Wrist
M/S Disorders by Job Title - December 1990

HETA 90-273
FL Thorpe & Co., Deadwood, South Dakota

JOB TITLE	Neck #/ N (%)	Shoulder #/ N (%)	Elbow #/ N (%)	Hand-Wrist #/ N (%)	
Cast	1/ 6 (17%)		0/ 8 (0%)	0/ 8 (0%)	0/ 8 (0%)
Solder	5/24 (21%)		3/26 (12%)	1/26 (4%)	8/24 (33%)
Grind/Polish	2/ 7 (29%)		0/ 6 (0%)	1/ 8 (13%)	3/ 8 (38%)
Plate	0/ 2 (0%)		0/ 2 (0%)	0/ 2 (0%)	0/ 2 (0%)
Wax	1/1 (100%)		1/ 2 (50%)	1/ 2 (50%)	1/1 (100%)
Wriggle	3/ 8 (38%)		3/ 8 (38%)	4/ 9 (34%)	6/ 9 (67%)
Bright Cut	7/ 8 (88%)		6/ 9 (78%)	4/ 8 (50%)	6/ 8 (75%)
Repair/Design	1/ 5 (20%)		0/ 8 (0%)	0/ 9 (0%)	1/ 9 (11%)
Pack/Ship	2/10 (20%)		0/10 (0%)	0/10 (0%)	3/10 (30%)
Supervisor	0/ 1 (0%)		0/ 1 (0%)	0/ 3 (0%)	0/ 2 (0%)
TOTAL	22/72 (31%)		13/80 (16%)	11/85 (13%)	28/81 (35%)

\# = Number of Employees with Symptoms Consistent with Work-Related Musculoskeletal Disorders which Began on Their Current Job

N = Number of Employees in Jobs as of December, 1990 minus the number of employees who had W-R M/S Disorders from another job.

Table 4

Characteristics of the Employees Diagnosed With Carpal Tunnel Syndrome

HETA 90-273
FL Thorpe & Co., Deadwood, South Dakota

	DATE SX BEGAN	JOB TITLE	DATE EVAL	PHALEN R	PHALEN L	TINEL R	TINEL L	NCS (Nl<4.4) R	NCS (Nl<4.4) L	WKS B/T DX & SURG	R-CTS SURG	L-CTS SURG	MD POST-SURG	LD POST-SURG
1	1/76	Bright	10/18/89	+	+	-	-	3.6	3.3	-	Refused	Refused	-	-
2	1/83	Grind	1/22/90	-	-	-	-	4.7	3.3	4	2/23/90	Not Rec	6 wks	-
3	6/85	Wriggle	7/10/89	+	-	-	-	2.9	2.8	1	7/20/89	7/27/89	7 wks	-
4	4/87	Grind	10/03/89	+	+	-	-	4.9	4.4	3	10/24/89	10/30/89	5 wks	+
5	3/89	Wax	6/19/89	+	+	+	-	4.2	3.4	8	8/14/89	8/29/89	12 wks	+
6	6/89	Solder	6/20/89	+	+	+	-	4.3	4.7	14	10/02/89	10/16/89	9 wks	+
7	2/90	Cast	2/05/90	-	-	-	-	"Slow"		27	10/31/90	Not Rec	6 wks	?

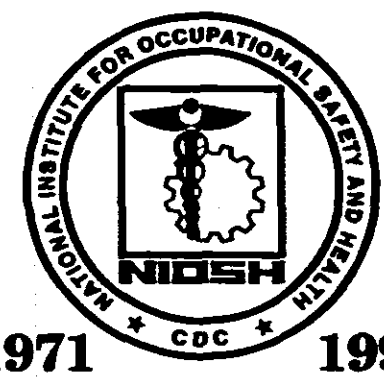
DATE SX BEGAN - Date the symptoms were first noticed by the employee
JOB TITLE - Job the employee was assigned when the symptoms were first noticed
DATE EVAL - The date the employee was first evaluated by a health care provider
PHALEN - Phalen's test result (description given in the recommendations section)
TINEL - Tinel's test results (description given in the recommendations section)
NCS (Nl<4.4) - Nerve conduction study performed by a hand held electroneurometer.
Normal median nerve reading are less than 4.4 milliseconds
WKS B/T EVAL - Number of weeks between the diagnosis of carpal tunnel syndrome and the surgery.
R-CTS - Date of the Right carpal tunnel release surgery
L-CTS - Date of the Left carpal tunnel release surgery
MD Post-Surg - Number of missed days of work following the carpal tunnel release surgery
LD Post-Surg - Were light or restricted duty jobs assigned following the carpal tunnel release surgery.

TABLE 5

CONDITIONS ASSOCIATED WITH CARPAL TUNNEL SYNDROME
(Adapted from Leach, 1968; Spinner, 1989)

HETA 90-273
FL Thorpe & Co., Deadwood, South Dakota

Endocrine Conditions		(diabetes mellitus, pregnancy, use of estrogens or oral contraceptives, acromegaly, myxedema)
Rheumatic Conditions		(rheumatoid arthritis, systemic lupus erythematosis, scleroderma, polymyalgia rheumatica, eosinophilic fascitis, gout, osteoarthritis)
Cardiac Conditions		(congestive heart failure, vascular shunts)
Blood Disorders		(amyloidosis, hemophilia)
Renal Dysfunction		(uremia)
Infectious Disorders		(tuberculosis)
Traumatic Injuries		(previous fracture of the carpal bones)
Tumors:	Benign	(gangliomas, lipomas)
	Malignant	(multiple myeloma)



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