HAND REHABILITATION IN OCCUPATIONAL THERAPY

FLORENCE S. CROMWELL
JANE BEAR-LEHMAN
EDITORS

Hand Rehabilitation in Occupational Therapy

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Publisher's Note
The publisher has gone to great lengths to ensure the quality of this reprint but points out that some imperfections in the original may be apparent.

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PRACTICE WATCH: THINGS TO THINK ABOUT

BOOK REVIEWS

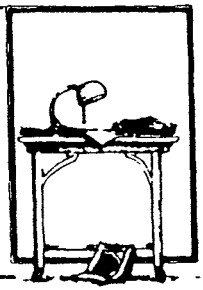
ABOUT THE EDITOR

Florence S. Cromwell, MA, OTR, FAOTA, is a well known and respected educator, clinician, administrator, and leader in the occupational therapy profession. She was President of the American Occupational Therapy Association for six years, 1967-1973, and she has been involved in a number of professional activities at state and national levels for 30 years. From 1970-1976, she was Associate Professor in the Occupational Therapy Department at the University of Southern California, Los Angeles, and Acting Chair for the last three years. Subsequently, she returned to clinical practice as Associate Director of the Los Angeles Job Corps in charge of Vocational Education. A consultant in occupational therapy program development and education since 1979, she has a rich background in health care concerns.

Jane Bear-Lehman, MS, OTR, is currently Training Specialist in the post-graduate occupational therapy program at New York University and an associate with Hand in Hand Rehabilitation, a private hand therapy practice in Long Island, New York. She was formerly Assistant Professor in the occupational therapy program at the University of Toronto. Ms. Bear-Lehman is a member of the American Society of Hand Therapists, and she serves as that organization's liaison to the American Occupational Therapy Foundation's (AOTF) Research Advisory Council.

Hand Rehabilitation in Occupational Therapy

FROM THE EDITOR'S DESK



With this issue, Volume 4 of OTHC comes unexpectedly to a close. Hand Rehabilitation is a popular topic and thus the numbers of papers generated have necessitated a double issue, for Fall/Winter 1987. We think the collection will become a valuable resource to all clinicians, as well as to educators and students. The authors represent a broad segment of those practicing today who are concerned with the treatment of disabled hands. Each is a skilled practitioner. I as "resident editor" am much indebted to Jane Bear-Lehman, my cohort for this effort. As Co-editor Jane provided the special knowledge of content, current practice and people that produced the quality of manuscripts now presented to you. In her introduction you can read more of what we have tried to produce for you.

As this volume ends it is time also for me to do some acknowledging of the many others who have aided and abetted my efforts during the four years I have served as editor. To you, our authors, who risked your publishing hopes in our hands, we are particularly indebted. We hope the experience has been one that persuades you to continue your writing efforts. To the members of the editorial board my grateful thanks for your hard work, timely completion of "assignments" and excellent support for the journal. Your ideas have been invaluable . . . your help inestimable.

As you know, many others who serve as reviewers get little if

any recognition in the process. They lend their special skills to a journal . . . because of their expertise. For those who served as manuscript specialist reviewers or as reviewers of other publications to be shared in our Book Review section, I tip my hat. Many of you have served numerous times, on short notice and with no complaints. You are an editor's delight. MUCHAS GRACIAS!

Ann Hyde
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Karen Paris
Stephanie Day
Diane Parham
Jane T. Herrick
Janith M. Hurff
Mary M. Evert

And doubtless others whose names my computer fails to produce at this moment. . . . To each of you, my heartiest thanks.

Finally, as I am completing my role as Editor of OTHC, I want to welcome the new Editor, my friend and colleague, Jerry A. Johnson, EdD, OTR, FAOTA, of Denver, Colorado. Well-known to you all as a long time leader in occupational therapy, Jerry brings rich skills and insights to this publication. We all look forward to her leadership in her new role.

As editor I am responsible for one additional issue, which because of the current double issue, has been put into Spring 1988, *The Occupational Therapy Manager's Survival Handbook*. Watch for it it promises to surprise you with its case approach to learning all those skills you never hoped to need. And do keep

your letters and comments coming, to both Jerry and to me. We are sincerely interested in hearing from you about suggested themes, ideas for content features, names of authors, whatever. And thank you for being there, fine friends and readers. Your comments have been encouraging and the fuel that has kept this project going strong.

Florence S. Cromwell
Editor

In This Issue

Inherent in the education of occupational therapists are the values of first appreciating, then evaluating and remediating through the use of "occupation" the physical and psychological effects which disease and injury bring to those so affected. As professionals, occupational therapists devote their efforts to perfecting therapeutic skills in order to enable patients to achieve maximum adaptation to the demands of their personal activities of daily living. A disease or injury that affects the spontaneous, reliable use of one's *hand(s)* impedes achievement of success in purposeful activity.

Persons with this kind of disability—and their numbers are growing in our fast, technology based society—need and challenge occupational therapy services as much as any patient group seen by occupational therapists. The incidence of injuries directly affecting the hand has risen dramatically in recent years; the survivor rate of those with congenital, systemic or neurological afflictions of the upper extremity also is producing significant numbers of persons needing help because of dysfunction in daily use of their hands. On the positive side, advanced surgical techniques now have begun to open new possibilities for both restoration and remediation of hand function.

Over the years, occupational therapists, quite naturally, have taken a special interest in developing specific evaluations and treatment procedures for the hand impaired population. The purpose of this issue of *OTHC* on Hand Rehabilitation in Occupational Therapy, therefore, is to offer a record of current theories and practical methods of occupational therapy programing for the patient, of any age, with decreased hand function. The content includes hand management discussions for the patient with de-

creased or loss of hand function regardless of cause, be it disease or injury. Further, case illustrations show the ways in which occupational therapists plan programs to incorporate those activities which the patient needs and uses in his daily roles, at home and at work or leisure.

The intent of this two volume issue of *OTHC* is not to provide a primer or a textbook on the scientific base for hand care, but more to offer the practicing therapist a breadth of the current concepts with clinical examples to facilitate problem based learning. The papers presented demonstrate an overview of the current thought and understanding of the basic sciences for shaping the course of hand management. For example, the principles of physiology and histology are drawn on to provide the rationale and to offer an explanation for the basis of wound care, scar management and early intervention treatment protocols. Innovations in hand care are shared as are some of the clinical reasonings and solutions for meeting the new challenges offered. The papers presented cover not only the needs of persons of given diagnostic groups, but also reviews of evaluation and treatment regimens relating hand care to theoretical models in occupational therapy.

In order to share this wealth of ideas and to preserve the writer's vitality and enthusiasms, I would like to extend special appreciation to those members of the *OTHC* Editorial Review Board who contributed their time and their direction for this edition. I would like to also extend a special thanks to Lillian H. Parent, Peggy Carter, Elaine E. Fess, and Catherine Trombly for their excellent clinical guidance. Thanks to Vicky Dingillo whose support has made this edition possible.

Jane Bear-Lehman

Hand Rehabilitation and Occupational Therapy: Implications for Practice

Jane Bear-Lehman, MS, OTR, OT(C)
Sharon Flinn-Wagner, MEd, CVE, OTR/L

SUMMARY. Occupational therapy for hands has been recognized as a speciality within the profession since the 1940s. The growing numbers of patients with acquired or congenital problems affecting their hands as well as the newer surgical procedures now available to restore lost function has challenged therapists. To manage the highly specialized needs of the complicated hand problems seen in the clinical setting, there is emphasis on perfecting technical skill. Equally required is the ability to remediate not only the physical dysfunction but also the patient's response to this dysfunction. For it is in this holistic approach to patient care that occupational therapy has its true strength in helping to successfully remediate the difficulties of the patient with a hand problem. Practical application of this principle is shown in a case study.

As an organ of touch the hand is adaptable and capable of performing an infinite number of daily living tasks utilizing tools, reach, and grasp. Inherent in the education of occupational therapists are the values of first appreciating, then evaluating and remediating through the use of "occupation" the physical and psychological effects which disease and injury bring to those so

We would like to extend our thanks to the Occupational Therapy Division at the University of Toronto for their support in the preparation of this manuscript.

At the time of writing Jane Bear-Lehman was Assistant Professor, University of Toronto, Toronto, Ontario; she is now affiliated with New York University, Occupational Therapy Department, 34 Stuyvesant Street, New York, NY 10003. Sharon Flinn-Wagner is Director, Center for Work Enhancement, Cleveland, OH.

affected. As professionals, occupational therapists devote their efforts to perfecting therapeutic skills in order to enable patients to achieve maximum adaptation to the demands of personal activities of daily living. A disease or injury that affects the spontaneous, reliable use of one's hand impedes achievement of success in purposeful activity.

The number of individuals with hand impairments is growing in our fast technological-based society. This population creates a need for and a challenge to occupational therapy services as much as any patient group seen by occupational therapists. The incidence of injuries directly affecting the hand has risen dramatically in recent years; the survivor rate of those with congenital, systemic or neurological afflictions of the upper extremity also is producing significant numbers of persons needing help because of dysfunction in daily use of their hands. On the positive side, advanced surgical technique now has begun to open new possibilities for both restoration and remediation of hand function.

HAND CARE AS A SPECIALITY

Hand rehabilitation and surgery as a speciality has been around for at least 40 years mostly due to the foresight of its founder Dr. Sterling Bunnell and the energy of his followers. His purpose for the development of this speciality was to promote better understanding and better professional standards in surgery of the hand. Aware that rehabilitation of the hand required much more than hand surgery, Dr. Bunnell consistently promoted, in his teachings, the development of a speciality team for hand care.[1] This team included the surgeon, the occupational therapist, and the patient.

One of the benefits of this form of specialization is the achievement of excellent clinical results. The opportunity to have repeated attempts at similar work and to have selective discussions and dialogue with others who share the same focus and skill can facilitate clinical perfection. This specialization can also have its dangers, as it can narrow the vision and magnify the significance of certain factors. The factors that are highlighted are usually the same factors that are valued as an index of profes-

sional success.[2] Since change in biochemical and biomechanical capacity of the hand can be quantitatively measured, recorded and traced, these results seem to be regarded as the bench marks of success. What is difficult to account for systematically are the ramifications of the injury or disease which ultimately serve to either facilitate or halt the success of the surgery and rehabilitation.[3]

THE ROLE OF THERAPY

The management of the person with the injured or diseased hand requires expertise and skill in clinically applying the tenets from physiology, anatomy and psychology. The main objective of the surgical and therapeutic intervention is to restore the functional capacity of the hand. A successful result cannot and should not be derived merely in degrees of range of movement, pounds of grip pressure or sensory touch-pressure threshold. The patient tends to measure the success based on satisfaction in the quality and the quantity of both appearance and performance.[4] Therefore, the ability for the patient to be able to resume his avocational and vocational pursuits is dependent not only on the technical skills of the team, but the team's art in encouraging and directing him through the required rehabilitation. This can be accomplished in therapy if the needs of the individual muscle, joint actions and coordination of the muscle as a process of the cortex of the brain are integrated with the will to complete an act.[1] This can be met only through purposeful activity, not through individual exercise. Physically, purposeful activity allows a repaired tendon to glide, contracted tissues to stretch and skin surfaces to feel. But equally as important, activity allows the patient to view his performance in something to which he can relate and to monitor his own achievement in overcoming the effects of the injury.

Back in the beginnings of our profession, occupational therapy was called upon once the patient was ready to begin a program of activity movement.[1] At that time it was the responsibility of the surgeon to provide the best surgical potential and the physical therapist who managed, along with nursing, the early post-operative wound, to provide the required early passive and active-as-

sistive range of movement. The advent and clinical application of the new thermoplastic splinting materials in the 1960s greatly altered the timing and the need for occupational therapy. New light weight functional splints could be fabricated to support not only the required post-operative alignment but also to facilitate the needed movement patterns. Since then, perfection in skills of clinical examination have also helped to shape the course and time of intervention.

The advances in hand surgery with its new potential to save more hands and to reconstruct musculoskeletal, CNS impairment or congenital anomalies has challenged (occupational) therapists. Consequently, occupational therapists have taken a special interest in developing specific evaluations and treatment procedures for the hand impaired population. One of the benefits of the refined methods and skills has been the ability to get measurable results which can be conveniently used to confirm the success of an intervention, importance of therapy, its timing and its sequence. Those findings conducive to statistical manipulation are the ones that are used to verify achievement not only to the surgeon and the insurer, but more importantly these numbers can graphically reinforce the patient. One of the major drawbacks in reporting only quantitative outcomes is the gaping absence of reports of qualitative performance, that is, the effects of interruptions in daily tasks and routines.

THE HOLISTIC APPROACH OF THERAPY

The needs of the patient who requires occupational therapy for hand rehabilitation should receive both physical and psychological attention. To start with, the therapist who offers hand rehabilitation in any setting must certainly address the physiological responses to disease or injury, surgical repair and eventual recovery. Through this process of recovery it is not only the physiological sequelae that is managed in occupational therapy, but also the ramifications of the disease or injury that require occupational therapy intervention for self-image, self-care, and restoration of the work-play continuum.

Throughout the history of occupational therapy there has been emphasis on the patient's will, desire and ability to recover. When hand function is impaired, the patient experiences a threat or interference in his usual performance of life skills. Some patients manage to adjust to these physical changes and maintain their activity level while others have difficulty adjusting. This lack of adjustment consequently creates a reduction in activity, or an absence of occupation, resulting in maladaptive responses. These negative responses may take the form of low pain tolerance, displaced anger, unfounded fears, and feelings of helplessness.[5] Approaches to identify and to intervene in these maladaptive behaviors are essential in hand care. The dilemma for the occupational therapist is in selecting a tool that is consonant with this population for measuring the magnitude of coping and adaptation in the presence of acute sensory-motor change. There are several assessments and corresponding treatment programs that have been adopted by occupational therapists to address adaptive and maladaptive behavior. Although the tenets are applicable, the Self Assessment of Occupational Functioning shows the most promise for detecting these changes in the hand injured patient.[6-8] It still requires, however, more work for validation.[8]

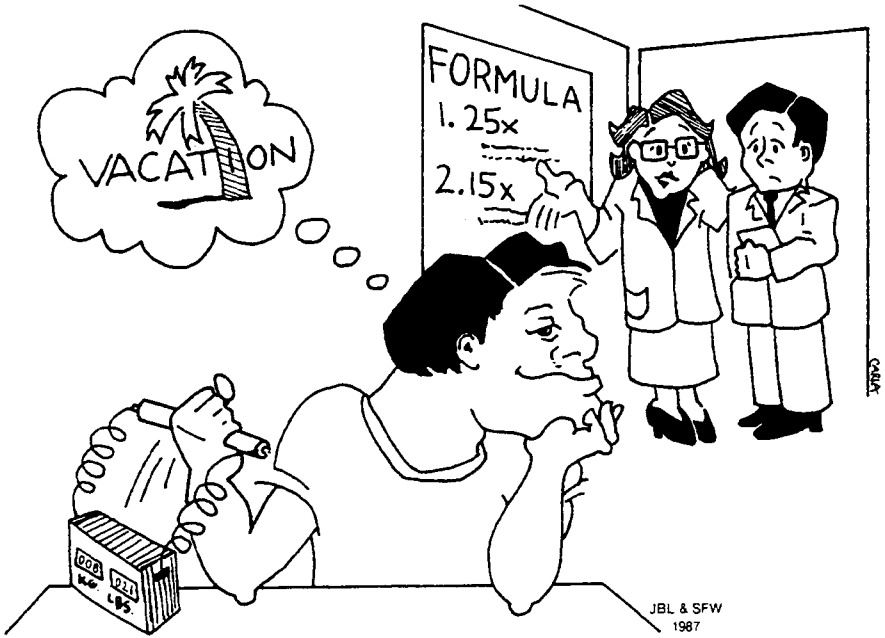
Clinically the interest in hand management appears to be on perfecting technical skills rather than the practice of the art of therapy.[3,9,10] In order to meet the needs for perfecting clinical treatments that are correlated to highly specialized hand care, there has been a strong allegiance to prefabricated, predetermined treatment protocols which do not include the behavioral component. On one hand, these protocols provide the needed direction for specialized acute care management, but on the other hand the question exists as to whether they are intended to be the complete program. With the strong holistic educational base in occupational therapy, how is it that we fall prey to the open traps of regimented treatment by protocol? It should be recognized that the use of protocols is a necessary step in learning the sequence and standard of technical care for hand management. At the same time the risk of limiting practice to following only a published protocol curtails success. For it is the richness of activity potential in occupational therapy that must surround the technical protocol to complete the therapeutic process. Without this, formula

following replaces clinical judgement and obviates the theoretical and scientific underpinnings of clinical practice. The cartoon, as shown in Figure 1, humorously depicts an extreme example of this concept.

CASE EXAMPLE

This description of a hypothetical case illustrates, how two theoretical domains with differing priorities affect the observations that a therapist makes and the treatment programs that are then developed.

> Mrs. Smith is a 34 year old assembly line worker who underwent a right median nerve decompression at the carpal canal on her dominant hand ten days ago. She has just had sutures removed and the therapist is beginning the post-operative evaluation.
>
> *THERAPIST A APPROACH*: *Observations* are made about the status of the patient's wound, the amount of hand edema, the gravity of the patient's post-operative pain, the return of sensory function, the ability of the hand to move and have functional strength. Several principles are used to explain the patient's recovery and they are based on kinesiological and physiological frames of reference. *Treatment* is based on rationale that includes scar maturation, nerve regeneration, veneous return of interstitual fluids, capsular adhesions, and gliding of the tendons and nerve.[11]
>
> *THERAPIST B APPROACH*: *Observations* are made with regard to physical status as above, but prior to developing a treatment program, additional information about the effects of carpal tunnel syndrome on the patient's performance is gathered. Questions are raised regarding the patient's motivations and goals, the stability of her routines and roles, and her level of personal skill satisfaction within the baseline of current activity levels that exist. *Treatment* is based on facilitating Mrs. Smith's confidence, encouraging her personal competence through an increased activity level that has been structured following post-operative guidelines and coordinated with a patient education program.[2,5]



WE'RE FOLLOWING OUR FORMULA—
SO WHY DOESN'T HE IMPROVE???

FIGURE 1.

The complexity and completeness of therapist B's approach is persuasive. However, in the rush of clinical activity, is the approach of therapist B truly accomplished? Certainly both approaches have some overlap, but it challenges us to look at each patient individually and base treatment on the specific needs and desires of each individual. On a larger scale, it also would serve us well and advance our area of specialized care, if with the same vigor that we adapt biomechanical approaches we also could put forward approaches that specifically relate to the special needs of our hand injured patients in achievement of not only the quantity but the *quality* of restored hand function.

In the articles that follow, the complexities of innovative treatment approaches for persons with hand dysfunction are shared. The type of physical impairment and the reaction to impairment varies among patients, but what patients do all have in common is some form of interruption in their ability to perform routine physical skills that resounds into the domains of their habitual and volitional activities. Through the approaches described and case studies discussed many styles and methods for achieving success in this comprehensive hand dysfunction remediation process will be identified. What also will be obvious to readers is the commitment and the encouragement the occupational therapy authors have conveyed to the patients. It is evident that the therapists' goals are to effectively and efficiently direct their patients having hand problems to regain their lost positions in society. Implicit in their willingness to openly share their art and their practice of therapy, so also will be their joys and rewards from helping a patient through this type of program.

NOTES

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Wound Management in Hand Therapy

Cecelia Holt Skotak, OTR
Susan M. Stockdell, OTR

SUMMARY. Competent wound management is critical to successful rehabilitation of the injured hand. The occupational therapist who treats patients with such injuries must know what is involved and how various treatment procedures and activities impact healing. This paper will review the physiology of wound healing, present a framework for evaluation of the wounded hand and provide practical suggestions for treatment.

PART I: PHYSIOLOGY

Occupational therapists have specialized training to recognize physiological and psychological responses to injury or disease, as well as the potential for these responses to impede a person's function. Therapists who treat patients with hand injuries must understand the skin's structure and physiological phases of wound healing and be able to recognize deviation from the expected course of events as well as potential complications. This guides the therapist in treatment planning and facilitates appropriate communication with the other professionals involved in the patient's care.

Cecelia Holt Skotak received her BS in OT from the University of Washington in 1982; Susan M. Stockdell received hers from the University of Missouri, 1981. She is a member of ASHT. Both are employed at the Arizona Hand Therapy Specialist, PO Box 140, Mesa, AZ 85201 where Ms. Stockdell is Director of Hand Therapy.

Skin is comprised of epithelial and connective tissue. Epithelial tissue lines the body's cavities and organs as well as forms the exterior surface or the epidermis of the body. Connective tissue or the dermis provides the integral, deep mechanical support for both anchoring and binding.[1]

Several layers of dead epithelial cells form the top outer layer of the epidermis; these cells are constantly sloughed and then replaced by new cells produced in the bottom layer through mitosis which then migrate to the superficial layer.[1] The dermis is composed of collagen fibers as well as elastic and reticular fibers. Blood vessels, lymph vessels, hair roots, nerves, and portions of the sweat and sebaceous glands are all located in the dermis.

Epithelial Tissue Healing

In wounds which involve the epidermal layer of the skin, such as first and second degree burns or abrasions, healing occurs in a simplified manner. The abrasion-type wound is initially filled with clotted blood and necrotic debris which eventually dehydrate to form a scab. In first or second degree burns, the dead epidermis remains on the wound or is elevated by a collection of fluid between the layers of the epidermis, thus forming a blister.[1]

In either case, the bottom layer of epithelial cells as well as those cells at the wound margins migrate into the wound, multiply by mitosis to resurface the wound, and then differentiate into mature epidermal cells. Once the wound is filled in, the migrated cells undergo mitosis to thicken the new epithelial layer. Upon completion of this process when there is a new surface to the wound, the scab sloughs off. If there is bacterial invasion at any stage, the superficial wound may be converted into a deeper wound.[1,2]

Connective Tissue Healing

The healing process is more complicated when an injury involves both layers of the skin and possibly even subcutaneous structures. This is frequently the case in hand injuries. Crush injuries, avulsion, lacerations, third degree burns, and surgical incisions are examples of such wounds. Wounds are classified by

the type of wound closure which is based on the degree of: host tissue injury, contamination by living organisms, and presence of foreign bodies.[3]

WOUND CLOSURE CLASSIFICATION

Primary closure. The wound is closed immediately provided that host tissue injury, contamination, and the presence of foreign bodies are minimal. The physician takes into consideration the mechanism of injury (e.g., a clean unused kitchen knife laceration to a clean hand) when making this decision. Healing of this type of wound is the most expedient.[4]

Delayed primary closure. The wound is not closed initially to allow for further debridement and/or to minimize the risk of infection.[3] The physician elects to complete closure when there appears to be no risk of infection.

Secondary intention healing. Again based on the mechanism of injury, the physician decides that surgical wound closure is contraindicated because the degree of host tissue injury, contamination, and presence of foreign body is too great thus the wound is allowed to close spontaneously (e.g., farmyard equipment injury, high pressure paint gun injury). This is also utilized in elective surgery in which there is a great deal of host tissue injury, such as Dupuytren's contracture excision.[3]

Treatment planning is augmented when the therapist also considers the nature/mechanism of each patient's specific hand injury and how these factors will effect the physiological course of events (see Table 1).

Wound Healing in Primary Closure

When connective tissue is injured, there are three phases of wound healing: inflammation, fibroplasia, and scar maturation. These phases will be discussed separately but in actuality occur as a continuum.

TABLE 1 NATURE/MECHANISM AND EXAMPLES OF INJURY

Consider which type of wound closure might be utilized and how healing would vary for different injuries.

Nature/Mechanism of Injury	Example of Injury
Amputation	skill saw, lawn mower
Crush	punch press
Avulsion	ring or rope avulsion
Laceration	clean kitchen knife, pork slaughterhouse knife
Puncture	nail gun
Thermal-heat/cold	burn, frostbite
Chemical	hydrofluoric acid
Electrical	entrance and exit wound
Explosive	gun shot wound, fireworks
High Pressure Injection	paint gun
Mutilating	wringer/roller, corn picker

Inflammation

Inflammation is a vascular and cellular response to tissue trauma, the purpose of which is to dispose of necrotic tissue, foreign material, and bacteria, thus preparing the wound for repair. It is nonspecific to the type of trauma whether thermal, mechanical, or bacterial and will be present in any damaged tissue.[2] The clinical signs of an acute inflammatory response are redness, local heat, swelling, pain, and loss of function.[4] During the first 5-10 minutes following an injury, constriction of the local vasculature occurs. Simultaneously, the vessel walls become lined with leukocytes, erythrocytes, and platelets.[5]

Active vasodilation follows, with increased blood flow and increased permeability of the small venules. It is possible that the vasodilation is induced by a local histamine action, which may explain a patient's complaints of the wound "itching." The endothelial cells, which swell and "round up," form separations between the cells, allowing plasma containing electrolytes and macromolecules to enter the site of injury.[2] Edema caused by this interstitial fluid will be present, as will redness and local heat caused by the increased circulation. Pain is thought to be caused by pressure on nerve endings, chemical mediators, increased neural sensitivity, or a combination of these factors. Lymphatic channels at the injury site are occluded by fibrin plugs which arise from the plasma. This occlusion prevents drainage of fluid from the area, thus localizing the inflammatory reaction.[5]

White blood cells (leukocytes) leave the vessels, concentrate at the injury site, and engage in phagocytosis of foreign substance. Ingested bacteria are partially digested by the leukocytes. As the leukocytes die, intracellular enzymes and debris are released into the wound to become part of the wound exudate or pus. Exudate can develop in the absence of bacterial contamination—without the wound being "infected"—but this interferes with healing. The enzymes contain protease and collagenase which solubilize connective tissue; consequently the wound must be kept clean in order to expedite completion of the inflammatory response.

Fibroplasia

During the first 24 hours of primary intention healing, the line of incision fills with clotted blood, and the wound is sealed. During the second day, reepithelization of the surface and bridging of the dermal cleft occur. The blood clot provides a structural scaffold along which the epithelial cells migrate. There are small tongue-like processes of cells protruding into the wound from the epithelial margins; these connect within 24 hours so that there is a surface covering of epithelium. Initially, the epithelium is very thin, but with proliferation of cells, it becomes several layers thick. Migratory fibroblasts (which have evolved from undifferentiated mesenchymal cells) move into the wound, proliferate

and synthesize scar. Components of the ground substance of connective tissue are synthesized initially, and later, collagen is formed. At this time,[5] granulation tissue (a highly vascularized tissue containing fibroblasts, capillary networks and other infiltrating cells) can be microscopically recognized in a wound which is healing by primary intention.[2,6]

By the fourth to fifth day, the wound space is filled with a highly vascularized, loose, fibroblastic connective tissue in which scattered collagen fibrils are present. Wound contraction begins to take place at this time through the movement of myofibroblasts from the periphery towards the center of the wound. By the fourth day, the wound has approximately one tenth of one percent of its ultimate strength.[7]

By the seventh day, the wound is covered by epidermis of near normal thickness. During the second week of healing, there is ongoing proliferation of fibroblasts and production of collagen. The collagen molecules are initially held together by weak physical forces and by hydrogen bonds. As the fibrils mature, the weak forces are replaced by covalent bonds (strongest type of chemical bond) to produce strong flexible fibers. At this point, the scar has increased vascularization as the capillaries are formed through endothelial budding. The fibrin scaffold has disappeared, and the inflammatory reaction should be completely subsided. Only the sutures and the epithelial bridge provide the wound with tensile strength. Carefully sutured wounds have approximately 70 percent of the strength of normal skin. If the sutures are removed on the seventh postoperative day, the wound alone has only 5-10 percent of the strength of normal skin.[5]

By the end of the second week, the basic scar structure is present, and with the accumulation of collagen, the tensile strength and rigidity of the scar increases. The vascular channels become compressed, and blanching of the scar begins. As a sufficient quantity of collagen is produced, the number of fibroblasts decreases. The synthesis of collagen is dependent on an adequate supply of nutrients (i.e., amino acids and vitamin C).[5,7] All of the sutures may be removed by this time and the wound is prepared for the next stage: scar maturation.

Scar Maturation

Function of the hand is dependent on the gliding of strong, dense connective tissues (i.e., tendon, bone, muscle, skin, and fascia) upon each other, thus allowing the great combination of movement, stability and strength necessary for everyday activities.[8] However, these tissues can be "cemented" together by the scarring process, thus preventing this gliding.

Scar tissue formed during fibroplasia is an enlarged, dense, protein structure comprised of collagen. The collagen fibers are randomly oriented and highly soluble; initially the union created is fragile. The maturation process (or change in form, bulk and strength) causes the weaving of the collagen fibers into a more organized pattern, allowing the wound strength to increase and adhesion to adjacent tissues to lessen.

By the fourth week, the scar tissue will have approximately 11 to 14 percent of its ultimate strength. At 60 to 70 days post-injury, the collagen content reaches approximately normal levels, at which point, the rate of collagen synthesis begins to decrease. The scar has now recovered approximately 25 to 35 percent of the skin's normal strength.[5] The mechanism by which scar maturation takes place is not definite but may be related to a continuous and simultaneous production and breakdown of collagen. When the rate of collagen breakdown is greater than production, a more supple scar develops. However, if collagen production is greater than the breakdown, the result may be a hypertrophic scar. Healed skin wounds ultimately achieve only 70 to 90 percent of the strength of unwounded skin, usually after 100 plus days post injury. A scar is never as strong, elastic or extensible as the tissue it replaces.[2,5]

Wound Healing in Secondary Intention Closure

When the wound is left to heal spontaneously by secondary intention, there is still an inflammatory response, fibroplasia, epithelial regeneration, and contraction of the wound margins. However, since this type of wound may have a significant amount of debris, the inflammatory reaction will be greater. Due to more extensive tissue loss which prevents wound margin ap-

proximation, wound contraction will play a greater role in decreasing the size of the defect. The defect must be slowly filled by granulation tissue before reepithilialization of the wound can occur. The healing process occurs less rapidly and results in more scar formation than with primary closure; consequently, there is greater potential for loss of specialized hand function.

The structure of the skin, epithelial and connective tissue healing processes, and the phases of wound healing (inflammation, fibroplasia, scar maturation) have been reviewed. Methods of wound closure as related to physiological response to injury and the differences between primary and secondary intention healing have been discussed. This information provides the scientific basis for wound management in hand therapy and will be applied to evaluation and treatment procedures in Part II.

PART II: EVALUATION AND TREATMENT

The ultimate goal of occupational therapy intervention with any patient population is to maximize the patient's potential for function. Injury to the hand impairs a person's ability to earn a living, perform self-care, fulfill family responsibilities, and pursue leisure time activities. The therapist must continuously evaluate the patient's response to the injury or disease and provide appropriate intervention based upon scientific knowledge of wound healing physiology. Thorough initial and ongoing assessment, with immediate and appropriate intervention, is the key to prevention of complications in the wounded hand. Complications of wound healing compromise the potential for optimal function, thus wound management must be addressed in the occupational therapy treatment plan of the hand-injured patient.

Wound Evaluation

As part of the overall upper extremity evaluation, the occupational therapist must be cognizant of the nature or mechanism of injury, the various factors which influence wound healing, and the patient's medical history (see Table 2). Assessment of circulatory status, signs indicative of infection, potential for second-

ary problems associated with the wound, and the patient's psychological response to the injury are all part of the initial evaluation and ongoing treatment program.

From the medical history it is crucial to note factors such as the patient's age, nature of injury, and course of treatment as these factors will influence the healing process and determine treatment procedures. Overall healing time and scar remodeling vary from individual to individual and within the same individual in

TABLE 2 FACTORS TO BE CONSIDERED IN ASSESSMENT

Factor	Consider
Tidy vs. Untidy	Degree of: Host tissue injury (sharply incised, well defined edges vs. irregular edges with tissue loss)? Contamination by living organisms? Presence of foreign bodies?
Site of Injury	Palmar vs. dorsal surface (potential for sensory deficit)? Crossing skin crease or joint? Dominant or nondominant hand?
Tissue(s) Involved	Skin? Tendon? Nerve? Vessel? Ligament? Bone?
Medical Care to Date and Planned Intervention	Debridement? Wound coverage/closure (primary or delayed closure; skin grafting or flap coverage? Previous patient instruction or explanation? Surgical procedures?
Physician's Philosophy and Protocals	What are physician's expectations of therapy? What methods are to be utilized? What is the ultimate plan and prognosis?
Factors Specific to the Individual Patient	Will the patient's: socioeconomic status, culture, religion, familial situation, physical environment, cognitive status and psychological adjustment effect their treatment?

accordance with his chronological age.[2] Current use of aspirin, anti-inflammatory medication, or chronic use of steroid medication will inhibit the inflammatory and fibroplasia stages of wound healing. Use of nicotine and/or intake of caffeine restricts peripheral blood flow. Patients with Diabetes Mellitus are less able to control infection once established; their skin contains high levels of glucose, thus survival of bacteria is favored. Any disorder of the immune system will make the patient more vulnerable to infection.[2,5,7]

Circulatory status of the injured area is assessed by observation of the skin color (i.e., purple, dusky, white, or pink), of the tissue turgor, and of the return of blood following manual pressure by the examiner. Inadequate arterial supply is indicated by slow return to an area of pallor. Inadequate venous drainage is indicated by a swift return to a purple, swollen area. Adequate blood flow is indicated by swift return to a pink area.[4]

Signs of infection include: prolonged inflammatory response (redness, heat, swelling, pain, loss of function), purulent drainage, and odor.[4] Red streaks extending proximally from the injured area and tenderness of the axillary lymph nodes indicate failure of the lymphatic system to localize the reaction.

Other physical findings of a wound which (if present), should be addressed are: drainage, skin maceration, active bleeding, hematoma, ecchymosis, exudate, wound margins (even, uneven, inverted, averted), suture placement, and skin tension (see Table 3). Hemorrhage within the wound space further stimulates the inflammatory response; the clotted blood is a rich substrate for bacterial growth.[5] Wound margins which are not even will heal, but with greater scar tissue formation and at a slower rate, due to difficulty in bridging the dermal cleft. Sutures are considered foreign bodies, which may contribute to the inflammatory response; consequently, if there is prolonged inflammation, removal of critically located sutures may be indicated.[2] Excessive wound tension produced by edema will cause additional tissue damage and inflammation, with a resultant increase in the fibroblastic response.[2]

It is essential to monitor the patient's psychological response to the injury. Complaints of pain which are disproportionate to the injury may be a sign that the patient is not coping with the

TABLE 3 PHYSICAL FINDINGS IN WOUND MANAGEMENT

Physical Finding	**Definition**
Inflammation	Localized protective response elicited by injury or destruction of tissues which serves to destroy, dilute, or wall off the injurious agent from the injured tissue.
Infection	Contamination by a disease producing substance or agent; establishment of a pathogen in host tissue.
Exudate	Material (cells, fluid, cellular debris) which has escaped from blood vessels and been deposited into tissues, usually the result of inflammation.
Drainage	
Purulent	Consisting of or containing pus.
Pus	A liquid inflammation product made up of cells (leukocytes) and a thin fluid.
Serous	Clear liquid (water-like in appearance) which has been separated during the clotting of blood from the clot and corpuscles.
Sanguineous	Bloody drainage.
Pallor	Paleness, absence of skin coloration.
Turgor	The normal pliability of living tissues.
Maceration	Moist, white appearance of skin; usually due to fluid accumulation within the wound or a moist environment (e.g. excessive perspiration within the dressing).
Ecchymosis	Bruising.
Hematoma	Collection of blood, usually clotted, in an organ, space, or tissue due to disruption in the wall of the blood vessel (s).

injury. However, before this assumption is made, all possible physical causes (i.e., overly constrictive dressing, pressure from splint, or infection), must be eliminated. Overly protective posturing, hiding of the injured area, ignoring the injury, or refusing to look at the wound should also raise concern that the patient is having difficulty coping with the injury.

By virtue of the amount of time the occupational therapist spends with the patient during treatment sessions, it is often the therapist who will have the greatest opportunity to observe these behaviors and to intervene. Empathize with the patient, listen to his concerns, allow him to express his anger; but at the same time instill confidence in him.[5] This is accomplished through education. The patient must realize from the first day of his treatment that he is the key member of the rehabilitation team. Therefore, he must have an understanding of what structures have been injured and the purpose of the treatment program. Educate him regarding those methods which he can utilize to bring about improvement. Provide opportunity for the patient to assist with evaluation and treatment techniques. When appropriate, have the patient actively use the extremity (i.e., after the inflammatory response has subsided and wound healing is firmly established), allowing for the precautions specific to his injury.

Treatment

By incorporating knowledge of wound healing physiology and the information gathered during evaluation, the therapist is able to provide effective wound care as part of the total occupational therapy program. However, it should be kept in mind that not all occupational therapists are trained hand therapists; and the degree to which the occupational therapist has full responsibility for providing wound management may vary with the physician's preferences and each facility's protocol. If the occupational therapist does assume responsibility for wound management, it is the therapist's ethical responsibility to obtain appropriate training. Even if the occupational therapist is not directly responsible for wound management, it may be necessary to provide certain aspects of wound care in order to complete portions of the occupational therapy treatment program (e.g., removing and reapplying

dressings prior to splinting). The occupational therapist should be able to recognize a potential complication and notify the professional who would provide intervention. The therapist who treats acute hand injuries must also be cognizant of wound healing progression (i.e., inflammation, fibroplasia or scar maturation), so that the total treatment plan is appropriate to the needs or events of each stage.

Cleansing

Cleanliness of the wound is maintained through a variety of methods. This may be achieved by frequent rinsing of the wound with sterile saline, a dilute solution of water and hydrogen peroxide, or the solution recommended by the referring physician. If there is clotted blood present, undiluted hydrogen peroxide will remove it, but the wound should then be rinsed with sterile saline due to the high toxicity of the hydrogen peroxide.

Whirlpool stimulates circulation, cleanses the wound, softens exudate in preparation for debridement, relieves pain, and relaxes spasm.[10] An advantage is that the patient may exercise while in the whirlpool; however, edema which may be increased by the dependent position must be monitored. Edema as a result of whirlpool may be minimized by utilizing cool water, completing active range of motion exercise while immersed, positioning the patient with his hand as high as possible (i.e., lowering the chair height, supporting the extremity in a horizontal position within the whirlpool), and by elevating the extremity immediately upon removal from the whirlpool.

The entrance site of pins and external fixators are a direct pathway for contamination, and therefore, must be monitored for drainage or inflammation and be cleansed frequently. Sterile cotton tipped applicators moistened with hydrogen peroxide or saline can be used to swab the area. Topical antibiotic ointments are sometimes prescribed for application at the entrance site.

Some physicians prescribe home wound care with frequent soaking in antiseptic solutions and independent dressing changes. This facilitates the approach that the patient has responsibility for therapy, and the understanding that the patient is an active member of the treatment team.

There should be an established understanding between the therapist and physician as to what extent and type of manual debridement may be completed by the therapist in general, as well as specific communication regarding each case. If manual debridement is required, sterile technique and instruments are used, and it must be done gently and meticulously to avoid trauma to viable tissue.

Placement of saline-moistened sterile gauze which is allowed to dry on the wound and removed when dry (wet to dry dressing) is another form of debridement. Formation of granulation tissue (which occurs by capillary proliferation) is stimulated by this process; this is due to the slight irritation of the wound surface which results in active bleeding thus bringing more new cells to the surface.

Patients should be instructed to clean their protective functional splints and stockinette liners daily, as they will perspire within them creating a warm, moist environment which is conducive to skin maceration and bacterial invasion. A paste made of water and baking soda will remove odor from plastic splints. Tubular stockinette liners (helpful in the absorption of perspiration and protection of the skin) should be machine or hand-washed with gentle soap between wearings; the patient should be provided with additional liners so that a clean one is always available.

Dressings

Dressings are used to: provide wound coverage, immobilize specific joints, and provide compression to control edema.

The immediate covering over the wound should be sterile. This portion may be moistened with sterile saline to absorb drainage and/or to debride exudate. Nonadhering dressings may be used directly over the wound to prevent sloughing of the wound surface upon removal of the dressing. If topical ointments are prescribed by the physician, the patient should be shown how to apply these without contaminating either the wound or the unused ointment. Utilization of a sterile applicator, cotton swab or tongue blade, will prevent contamination of the wound. A new applicator is used each time additional ointment is obtained from

the container to prevent contamination of the unused portion by an applicator which has touched the wound.

The dressing should be applied with respect to those areas which are susceptible to pressure or movement. Bony prominences and areas where nerves are superficial need to be protected from pressure. Placement of gauze fluffs between fingers prevents maceration of the adjacent skin surfaces and pads the phalangeal condyles; however, digital nerves can be irritated if gauze fluffs are pressed too firmly into the web spaces. If a plaster or plastic splint is incorporated into the dressing, to provide contour and support, the bony prominences must be accounted for. This is accomplished by incorporating padding into the splint or shaping of the material to distribute pressure. Special consideration is given to external fixators and pin sites which require dressing coverage but must not be disturbed. Care must also be taken not to shear a skin graft as a result of friction by a loose dressing or movement of the adjacent joints.

If a patient is to complete wound care at home, it may be helpful to provide dressing supplies to ensure continued utilization of the proper type of dressing. If a patient can not complete the needed dressing changes independently he needs to be seen more frequently until this goal is reached, or a significant other should be instructed in proper technique.

Positioning and Immobilization

The intrinsic plus position of the hand is considered optimal for prolonged immobilization. This includes: wrist at 20 to 30 degrees of wrist dorsiflexion, 70 degrees of metacarpalphalangeal (MCP) joint flexion, 0 to 10 degrees proximal and distal interphalangeal (IP) joint flexion, and the thumb in palmar abduction. The purpose of this is to place the collateral ligaments of the MCP joints and the volar plates of the IP joints in their lengthened position which prevents joint contractures and also to maintain the first (thumb-index) web space.[11]

Patients often complain that this position is uncomfortable. If immobilization will not be prolonged, or if the splint/dressing is removed intermittently, as done for early motion programs, this possibly extreme positioning may not be necessary. But the pa-

tient must be regularly monitored for: intrinsic muscle tightness; maintenance of the distal transverse arch, the proximal transverse arch, and the longitudinal arch; contracture of the web spaces; flexion contracture of the IP joints; and wrist mobility. If subcutaneous structures (such as tendons or nerves) have also been repaired, protection of the repair would dictate the position of the hand.[11,12]

If a dressing is to be accommodated within the plaster or plastic splint, it should be applied prior to fabrication of the splint so that the bulk of the dressing is allowed for. If a plastic splint is used, it is helpful to plan ahead and utilize the appropriate thermoplastic splinting material in anticipation of decreased edema and progressively smaller dressings. In general, those materials which drape and conform well do not tolerate reheating and remolding as well as those which have more rigidity. When determining which type of dressing and splint to utilize, consideration must be given not only to what is best therapeutically but also to what will be practical for each patient. The patient should be shown how to donn and doff the splint and apply the dressing properly. If there is any question of comprehension, have the patient demonstrate his ability to do this prior to leaving the clinic. Alert the patient to potential problems which they should be aware of at home, i.e., skin irritation, tight straps, pressure areas; what he should do to alleviate these and how to contact the therapist for assistance.

Patient Education

Successful hand rehabilitation requires active participation of the patient. Education regarding the anatomical structures injured and their function, sequence of events to be expected during the healing process, the goals of treatment, and the expected outcome is helpful in relieving the patient's apprehensions and establishes that the patient is part of the team. The patient must be educated regarding what he can do to achieve the goals of treatment while in therapy but more importantly during the remainder of each day. This should include edema control techniques, appropriate activity level, awareness of environmental temperature,

home wound care techniques, range of motion exercises, and activities of daily living.

Verbal and written instructions usually facilitate the required compliance. Compliance is also enhanced by verbal reinforcement from the therapist when application of instruction is noted. Sharing objective measurements with the patient provides feedback that his efforts have been successful and is immediate reinforcement.[13]

Potential for complications secondary to edema exist in any wounded hand. The best cure for edema is prevention. Consistent elevation, with the hand above the elbow and the elbow above the shoulder level, is necessary for gravity-assisted lymphatic drainage. A helpful explanation frequently used is that of a drop of water flowing "downhill" from the fingertips to the heart. Slings are usually not appropriate, as they support the patient's arm with the shoulder abducted and the extremity in a dependent position, thus obstructing lymphatic drainage, restricting motion and potentially causing stiffness of the shoulder and elbow.[14] Various methods may be utilized to achieve the needed elevation, e.g., pillows, foam elevators, IV pole suspension, hand-on-head position; these should be discussed specifically with the patient so there is no chance for misinterpretation. Whatever method is used, it is important to continuously elevate the hand and support the weight of the arm to prevent shoulder discomfort. Acknowledge to the patient that this is inconvenient, but emphasize that the need to elevate the extremity will be short term if he is consistent. Educate the patient that it is imperative to prevent edema because once established it is very difficult to treat, and will ultimately compromise the function of the hand.

The patient must also be educated regarding the possibility of a prolonged inflammatory reaction and the potential for infection secondary to excessive activity. The lymphatic system of the wounded hand has already been overburdened; thus, a high heart rate with resultant increase in blood flow to the hand will only tax the system more. Any activity which raises the heart rate beyond the resting level is too much during the acute inflammatory phase of wound healing. It is also difficult for the patient to be consistent with an elevation program when active.

Environmental temperature extremes—of heat, which would cause excessive perspiration within the dressing resulting in skin maceration, or of cold, which would restrict peripheral blood flow to the injured area (e.g., a replantation exposed to extreme cold) are to be avoided.

Instruction as to the type and frequency of active motion as well as use of unrestricted joints should be provided. If active range of motion is encouraged to reduce edema and prevent stiffness, it must be through the full arc of motion available with a "pumping" muscle contraction. "Wiggling" the fingers is not effective. If healing is by secondary intention, there must be a well-defined balance of immobilization and active motion. The goal is to prevent an inflammatory reaction but to maintain tendon gliding, joint mobility, and thus specialized hand function. Explain these principles to the patient but do not assume their correct interpretation, instead provide specific instruction regarding the motion program.

In all patient education programs, the occupational therapist must assess the patient's cognitive abilities as related to their ability to follow the instruction. In hand therapy this is usually not assessed through formal cognitive evaluation but rather consistent monitoring for the desired result as well as the patients' subjective response. It is important to adjust the quantity of instruction provided and the manner in which it is provided to each individual patient.

SUMMARY

The histology of skin and physiology of wound healing have been reviewed. A frame of reference for assessing and treating the person with a wounded hand has been presented. Principles of wound care, including methods of cleansing, dressing applications, positioning and immobilization as well as patient education have been addressed. Practical application of this information should aid the occupational therapist in assisting the patient to maximize the function of their hand through prevention of unwarranted wound healing complications.

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Clinical Management of Scar Tissue

Mary C. Kasch, OTR, CVE

SUMMARY. This paper will review the physiology of scar formation including the properties of wound healing and scar remodeling. A clinical scar management program that includes evaluation of scar adhesions and use of a variety of therapy interventions to minimize the formation of scar will be described. Use of compression, massage, splints and functional activities is included in this program. The information is applicable for the general occupational therapist who sees patients with hand dysfunction as well as a therapist specializing in hand rehabilitation. Every therapist who treats hand trauma must be familiar with the sequence and the properties of scar formation in order to reestablish tendon gliding and facilitate early remodeling of scar tissue. Many treatment techniques can be directed toward scar adhesions and no one method is totally effective when used alone; used together, these techniques can positively influence scar formation and restore maximal hand function.

The hand is made up of dense connective tissue and movement occurs when these structures are able to glide relative to one another. Any disruption of this process results in loss of movement and decreased hand function. Peacock introduced us to the concept of "one wound, one scar"[1] which means that wounds secondary to injury or surgery will form one scar during the healing

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process and all surrounding structures will be included in the scar, despite efforts to reapproximate all the involved structures by layer. For surgeons, this concept has led to placing incisions in the least adherent areas and using zigzag patterns that will minimize functional loss. Therapists must analyze the location and depth of the wound, based on the medical and operative reports, to determine the expected restrictions that will result from scar adhesions. Treatment is based on this careful analysis and is also influenced by the length of time since injury or surgery. Thorough knowledge of the biology of scar formation is critical to effective treatment.

An acute inflammatory process is initiated within hours when the tissues are disrupted through injury or surgery, causing vasodilation and local edema as well as migration of white blood cells and phagocytic cells to the area. The phagocytes remove tissue fragments and foreign bodies and are critical to healing. The inflammatory process can subside or persist indefinitely depending on the degree of bacterial contamination.

Fibroblasts in combination with associated capillaries, begin to invade the wound within the first 72 hours and gradually replace the phagocytes. Collagen fiber formation follows the invasion by fibroblasts, so that by the end of the second week, the wound is rich with fibroblasts, a capillary network and early collagen fibers. The increased vascularization results in the erythema of the new scar. Then during the third to sixth weeks, fibroblasts are slowly replaced with scar collagen fibers and the wound becomes stronger and more able to withstand progressive stresses.

Madden has stated that "by three weeks, the normal incised and sutured wound has less than 15 percent of its ultimate tensile strength."[2] This strength continues to increase for three months or longer. The collagen metabolizes and synthesizes during this period of time, so that new collagen replaces old while the wound remains relatively stable. Covalent bonding between collagen molecules leads to dense scar adhesions and the formation of whorl-like patterns of collagen deposits that may be altered as the scar architecture and collagen fiber organization within the wound changes over time. Myofibroblasts, fibroblasts with prop-

erties similar to smooth muscle cells, may be present and cause a shortening of the wound due to their contractile properties.

Tissues which have restored gliding have different scar architecture than those which do not develop the ability to glide. With gliding, the scar resembles the state of the tissues prior to injury while the non-gliding scar remains fixed on surrounding structures. Controlled tension on scar has been shown to facilitate remodeling. Scar formation is also influenced by age and the quantity of scar deposited. Methods of altering and remodeling scar formation will be discussed in the clinical program section.

EVALUATION

Background

A patient may be referred to the occupational therapist at any point during the healing process. Many patients benefit from early treatment, such as passive motion of a repaired tendon within the first few days following surgery but for many others, the referral for treatment occurs long after the injury when "nothing else has helped." The therapist must be prepared to treat a patient referred early or late, knowing that the greatest challenge and frustration may be with an injury that occurred several weeks or months prior to the initiation of therapy.

If the injury or surgery is recent, the therapist must keep in mind the properties of wound healing to determine how much protection and how much movement should be given to the healing structures. While early motion is desirable, an overly aggressive therapy program can produce unwanted tissue damage. Therefore, precautions should be discussed with the referring physician at the onset and during the course of treatment. Healing may be influenced by the use of medications, such as Prednisone, which will delay healing. Other factors such as the patient's general medical condition, other diagnoses such as diabetes or arthritis, and factors of hand dominance and age may also effect the rate of healing.

Topographic Evaluation

The scar should be observed and palpated for color and texture. A newly formed scar (within the first six weeks or sometimes longer) will look red, or reactive, and localized edema may be present. The therapist should feel the scar: is it indurated (hardened) or boggy (spongy) feeling? Is the scar thick and raised? A scar may become hypertrophic, or thickened, even if it does not appear reactive. Keloids, a condition characterized by excessive fibrotic growth of the scar, may develop with very dark skin and should be treated as early as possible. A scar will often adhere in specific spots but not along its entire length. The therapist should look for those spots by feeling along the length of the scar for areas that dip and cannot be manipulated with gentle circular massage. A reactive scar that persists into the third month post-repair may indicate an inflammatory response that may require medical attention. Administration of non-steroidal anti-inflammatory drugs may be prescribed by the physician to help control inflammation.

The therapist may notice early signs of reflex sympathetic dystrophy (RSD) during evaluation of a patient who is referred for scar management. Since RSD may be unrecognized in its early stages, the therapist should make careful note of symptoms that include extreme pain, swelling, increased sweating, shiny skin and positioning of the hand during the inflammatory period. RSD is not a normal response to injury and the patient should be seen by the physician for diagnosis as soon as possible. Once diagnosed, the condition should be treated with a specified program of active motion, functional activities, edema control techniques and pain control techniques to reduce the symptoms as quickly as possible.

Range of Motion Evaluation

Passive and active motion should also be assessed unless it is contraindicated by the recent surgery or injury. Both the injured and non-injured hand should be evaluated for comparison to each other. The tests that follow are designed to allow the therapist to compare performance within the affected hand.

During passive ranging, the therapist should evaluate whether

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Joint Surg (Am) 5:233-4, 1973 Occupational Therapy Management of Tendon Transfers in Persons with Spinal Cord Injury Quadriplegia Ana G. Verran, OTR Jane McMullin Baumgarten, OTR Karen Paris, OTR SUMMARY. Upper extremity surgical reconstruction can play an important role in helping the spinal cord injured quadriplegic patient achieve maximum independence in a variety of activities of daily living. The transfer of the brachioradialis to the extensor carpi radialis brevis, the brachioradialis to the flexor pollicis longus, and the posterior deltoid to the triceps each provide opportunities for functional improvement in this patient group. The occupational therapist's understanding of functional potentials and problems unique to spinal cord injury provides a realistic perspective to the team on potential benefits of each surgery. The occupational therapist also plays a critical role in identifying appropriate surgical candidates, in establishing treatment goals with the patient, and in administering a carefully planned post-operative treatment program.

Patients with a C5, C6, and C7 level of spinal cord injury have

differing potentials for independence with activities of daily liv

ing (ADL) based on a number of factors. Upper extremity brac

ing is a traditional, and still valuable approach used by the occu

pational therapist to improve functional potential. 1 Upper

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extremity reconstructive surgery through tendon transfers is a

more recent method used to enhance functional capabilities. Sur

gical procedures are selected carefully to augment arm and hand

function because the person with quadriplegia relies solely on his

upper extremities to accomplish all ADL. The ability to achieve

tenodesis in the C5 quadriplegic patient who lacks it, will en

hance functional potential for performance of some self-care

tasks. Although muscles available for transfer are limited in this

patient group, the brachioradialis has been successfully transfer

red to provide extension of the wrist and obtain tenodesis prehen

sion. Patients with C5 or C6 quadriplegia lack triceps function.

Provision of active elbow extension through a tendon

transfer

provides elbow stability during prehension and allows the indi

vidual to raise the arm overhead. The patients with C6 or C7

quadriplegia may have tenodesis prehension adequate for only

light functional activities. Surgical reconstruction allows lateral

prehension independent of wrist position. Many ADL tasks in

volving manipulation of tools are benefitted. Occupational ther

apy intervention in the form of both neuromuscular assessment

and treatment is essential in integrating the function allowed by

these surgeries into the performance of ADL tasks and each pa

tient's unique lifestyle.

This article focuses on three surgical procedures commonly

used with patients at Rancho Los Amigos Medical Center

(RLAMC), who have C5, 6, and 7 spinal cord quadriplegia. To

facilitate setting of attainable goals by therapists and patients,

realistic functional expectations are presented for each surgery.

Physical and psychosocial criteria for determining appropriate

candidates are described. The occupational therapist's post-sur

gical management for the tendon transfers is also reviewed.

RECONSTRUCTIVE SURGICAL PROCEDURES

Brachioradialis to Extensor Carpi Radialis

Brevis Transfer (BR to ECRB)

The BR to ECRB tendon transfer is performed in order to ob

tain or augment wrist extension strength so as to provide useful

tenodesis function to the hand. 2 This reconstruction involves 157

transfer of the brachioradialis muscle to the extensor carpi ra

dialis brevis tendon through interlacing of their tendons. The sur

gery results in active extension of the wrist. It is typically per

formed on the patient with C5 quadriplegia who demonstrates

fair-plus to normal deltoid and biceps strength and zero to fair

strength in wrist extension. While the surgical result may free the

patient from having to use a ratchet wrist-hand orthosis, it may

not eliminate the need for bracing entirely. Bracing in the form of

a wrist-driven wrist-hand orthosis (WDWHO), also known as the

flexor hinge hand splint, may still be useful since tenodesis by

itself may not provide sufficient prehension strength to pick up

an object or hold a tool.

The BR to ECRB transfer is sometimes followed by a second

reconstruction. This procedure, termed the "key grip" surgery

was designed to enhance the lateral movement of the thumb to

wards the index finger which occurs in tenodesis as the wrist is

extended. 2 This involves a tenodesis of the flexor pollicis brevis

and longus tendons. The lateral pinch resulting from this surgery

is passive and can occur only during extension of the wrist. A

positive correlation exists between wrist extension strength and

the pinch power obtained from the key grip procedure. 3 This was

demonstrated in a follow-up study of ten hands in nine patients,

in which prehension strength ranged from 0 to 17.7 pounds for

3.5 cm sized test objects. One drawback of the procedure ap

peared to be a progressive loss of pinch power over time which

may have been secondarily attributed to stretching of the extensor

tenodesis and bowstringing of the flexor pollicis longus tendon.

The tenodesis hand function achieved through both of these

surgeries, by themselves or in conjunction with bracing, can do

much to enhance functional skills of the patient with C5 quadri

plegia. Despite the drawback cited above, seven out of the nine

patients contacted for long-term follow-up of the key grip sur

gery continued to feel that it enhanced their functional indepen

dence. 3 Skills which involve prehension of utensils and tools are

particularly benefitted. Patients report that tasks such as feeding,

light hygiene and grooming and desk top skills such as writing

are easier because they have better control of the utensil or tool.

Some patients with particularly good results are able to eliminate

use of an orthosis. On the other hand, improvements in ability to

fully dress the upper and lower extremities may not be a realistic

outcome of these procedures, especially if reconstruction has

been unilateral. Total body dressing requires additional muscle

function than those affected by these surgeries. However, the

patient may be able to use the prehension to assist with removing

clothing.

Brachioradialis to Flexor Pollicis Longus

Transfer (BR to FPL)

The BR to FPL tendon transfer allows an active lateral pinch

which is independent of tenodesis prehension achieved by wrist

extension. 4 The surgical procedure involves release of the brach

ioradialis from its insertion and its suture into the flexor pollicis

longus in the forearm. A permanent screw is inserted longitudi

nally into the thumb tip to provide stabilization of the interpha

langeal joint, with movement of the thumb pad to the radial side

of the index finger to permit a lateral pinch. The pinch achieved

is not dependent on wrist position which is in contrast to the

lateral pinch resulting from the "key grip" and BR to ECRB

surgeries. This active pinch allows a patient to pick up objects

more precisely and in any degree of wrist flexion or extension.

The patient accomplishes thumb opening by passive flexion of

the wrist unless active thumb extension is present.

It has been found at RLAMC that this surgery provides func

tional benefits for many C6 and C7 quadriplegic patients. This

group of patients usually has good to normal brachioradialis mo

tor function and fair-plus to normal wrist extension and pectoralis

major strength. The C7 quadriplegic group additionally has a

strong (fair-plus to normal) triceps muscle and strong extrinsic

finger and thumb extensors. Neither group has functional prehen

sion ability other than through tenodesis function of the hand.

Without surgery this prehension is often limited to lightweight

objects and is dependent on an extended position of the wrist. To

compensate for the limited prehension, patients at these two lev

els may utilize the WDWHO to perform many ADLs.

Follow-up study of the BR to FPL tendon transfer indicated

that patients average approximately four pounds of pinch with

the wrist extended or in the neutral position and slightly more Verran, Baumgarten, and Paris 159

than half of this in wrist flexion. 4 Prior to the surgery, lateral

pinch averaged 0.15 pounds with the wrist extended and 0

pounds in the neutral position or in flexion. Of the 15 patients in

this study, 13 felt that they had significant functional improve

ment in their hand. In the clinic an improvement in patients'

ability to pick up and hold objects ranging from soft drink cans to

coins and cards was observed. Writing without adaptive equip

ment has also been possible. Most patients state improvement in

their ability to feed themselves, particularly with holding a knife

to cut food. Many report increased efficiency in their ability to do

light hygiene and grooming activities such as washing the face,

brushing their teeth, and combing the hair, presumably because

the transfer allows more secure prehension of tools and utensils.

The ability to manage fastenings and manipulate clothing in

dressing the upper and lower extremities is another skill which

has been facilitated for many patients. Most patients who used a

WDWHO before surgery no longer require it afterwards.

Wrist extension strength and triceps function have been dem

onstrated to be positively correlated with the amount of pinch

strength achieved with the BR to FPL transfer. 4 Patients with

good to normal wrist extension strength appear able to oppose the

wrist flexion force exerted by the brachioradialis in its transferred

route. Patients with fair-plus or weaker extension of the wrist

may be unable to oppose this force and avoid maximal contrac

tion of the brachioradialis to prevent wrist flexion. The relation

ship between triceps function and prehension strength is dis

cussed in the following section.

Posterior Deltoid to Triceps Transfer (PD to TR)

The PD to TR procedure is used to gain active elbow exten

sion. 25 During the surgical procedure the posterior

portion of the

deltoid is extended using a free tendon transfer from a toe exten

sor or the tibialis anterior to the triceps aponeurosis.

The PD to TR surgery is most commonly performed on the C6

quadriplegic patient who lacks triceps function and who would

benefit from the ability to actively extend the elbow. As was

previously stated, triceps function has been positively correlated

with prehension strength in the BR to FPL transfer. 4 Two reasons

for the correlation between triceps function and strong pinch

have been suggested. The most obvious reason is that patients

with strong triceps function are likely to have normal strength of

the brachioradialis because of its higher cervical innervation. The

second reason relates to the action of the brachioradialis as an

elbow flexor. With the elbow extension achieved by triceps func

tion, an antagonist is provided against which the brachioradialis

can contract without causing excessive elbow flexion when the

patient pinches. Because of this relationship, the surgeon may

elect to perform PD to TR reconstruction in conjunction with or

following the reconstruction of lateral pinch.

Overall results of the PD to TR transfers performed at

RLAMC have been good. In a follow-up study of 19 transfers on

18 patients, nine patients achieved good triceps strength and four

achieved fair-plus strength. Three extremities achieved poor-plus

strength. Three transfers resulted in muscle strength of zero to

trace and were considered failures. 5 Active shoulder and elbow

range of motion was maintained in all cases. Fifteen patients

stated that they received functional gain from the surgery. Clini

cal observations have noted improvement in ability to raise the

arm above the head for self-care and household activities. Ten

patients in the follow-up study stated that they had improved the

ability to brush the teeth, comb the hair, wash, and use make up.

Also seen in the clinic have been improvements by body han

dling skills such as ability to turn in bed and come to a sitting

position. Extension of the elbow to steer the wheel or operate

hand controls during driving has been another beneficial out

come. The follow-up study found that driving ability was posi

tively affected in about half of the patients. Six patients who

were not driving before the surgery were able to drive after

wards. Improvement in ability to perform a depression type

transfer in and out of the wheelchair may not be realistic unless

the reconstruction is done bilaterally and fair-plus to good elbow

extension strength is achieved. Only four of the patients from the

follow-up study were able to do sliding board transfers from

wheelchair to bed following the surgery. Two of the patients

could do this prior to the tendon transfer. Other functional

changes observed include improvement in ability to relieve is

chial pressure either by shoulder depression or forward lean and

in the ease of manual wheelchair propulsion. 161 PROBLEMS RELATED TO SPINAL CORD INJURY WHICH AFFECT SURGICAL RECONSTRUCTION

In a spinal cord injury, unlike an isolated peripheral nerve in

jury, muscles available for tendon transfer are limited to those

innervated by the neurological segments at or above the level of

injury. While a person with a peripheral nerve injury is likely to

have a normal hand to assist with performance of ADL, the spi

nal cord injured individual usually has bilateral upper extremity

motor deficits. When availability of strong muscles is limited,

care must be taken so that the surgical procedure chosen will

maximize functional gain. 6 Failure to do this may sacrifice a

functional muscle in an individual who is already functionally

compromised.

Damage to the sensory pathways results in clinically signifi

cant sequelae. Deficits may include loss of pain and temperature,

pressure and proprioceptive sensation at and below the level of

the lesion. This places the quadriplegic hand at risk for develop

ing skin problems from burns, abrasions, or unrelieved pressure.

This becomes especially significant during post-surgical manage

ment, when the patient may have to rely on others to check skin

integrity beneath a splint.

Absent sensation does not preclude consideration for surgery

but is a factor to be considered along with strength and range of

motion (ROM). The quadriplegic patient must compensate for

deficits in hand sensation through the use of vision and may have

difficulty using both hands simultaneously. 2 An individual en

dowed with additional muscle power through a tendon transfer

may be unable to effectively use the new found motor ability

unless he is able to look at his hand while using it.

Spasticity is a special concern in evaluating the spinal cord

injured hand because it may significantly limit function. 6 Invol

untary spastic motions which occur below the level of the lesion

can act to dislodge the alignment and attachment of surgically

transferred tendons and endanger the result of the surgery. Spas

ticity and spasms may also interfere with a patient's ability to use

the upper extremities functionally by limiting ability to relax a

muscle or group of muscles. Inability to achieve full hand open

ing through tenodesis is an example of this type of problem if

spasticity is present in a patient's finger flexors.

Many spinal cord injury patients develop contractures where

spasticity is present. When spasticity is accompanied by muscle

imbalance across a joint there is a tendency toward development

of deformity. A common example is the elbow flexion contrac

ture seen in the patient who has functional, but spastic biceps,

and lacks triceps function. This contracture limits the range of

motion available for functional activities such as feeding, light

hygiene and grooming, depression or sliding board transfers and

wheelchair propulsion. Contractures must be eliminated prior

to performance of a tendon transfer. The active muscle power

achieved by a tendon transfer will not overcome the restrictions to

passive motion caused by spastic deformity.

Partial paralysis of the arms and total paralysis of the trunk and

lower extremities frequently dictate the manner in which ADL

are performed. Most light hygiene and grooming activities and

upper extremity dressing are done from a wheelchair. For the

vast majority of these patients, lower body dressing is done in

bed and bathing is done from a shower or bath chair. Since im

paired function of the bowel and bladder also occurs, the patient

with quadriplegia has unique needs for self-care in these areas

too. In addition, sensory deficits over the buttocks require hourly

relief of ischial pressure to prevent skin breakdown. The ability

to transfer in and out of a wheelchair independently is also of

particular importance to these patients who rely on wheelchairs

for mobility. Maximum prehension, strength, and coordination

are necessary to perform ADL. The occupational therapist in

volved in the selection of surgical candidates needs to carefully

evaluate the impact of any proposed surgery on an individual's

function and goals prior to recommending the specific operative

procedure. GUIDELINES FOR SELECTING SURGICAL CANDIDATES

Patients must be carefully selected as candidates for each of

these surgical procedures. There are well-defined physical crite

ria for consideration as a surgical candidate, but of equal impor

tance is the patient's emotional readiness for surgery, under

standing of its benefits, physical and social support systems, and

the patient's individual goals. Surgical candidates must be able to 163

follow and participate in a structured post-operative treatment

program and adjust to a temporary increase in dependency due to

post-surgical restrictions.

Physical Criteria

Briefly, the physical criteria for the BR to FPL transfer include

the (1) patient approximately one year or longer post-injury;

(2) good to normal brachioradialis strength; (3) fair-plus

to good

wrist extension strength; (4) full passive ROM in elbow, wrist

and hand; (5) adequate tenodesis positioning of finger metacar

pophalangeal and interphalangeal joints; and (6) absence of spas

ticity in the wrist and hand musculature, and preferably no spas

ticity in the shoulder and elbow. Minimal spasticity is acceptable

in these joints providing it does not interfere with performance of

ADL.

The physical requirements for the BR to ECRB transfer are the

same except for candidates for this surgical procedure will pre

sent with zero to fair strength in the wrist extensors.

The physical requirements for candidates for the PD to TR

surgery include (1) the patient one year post-trauma or longer;

(2) fair-plus to good deltoid strength, particularly the posterior

deltoid; (3) fair-plus to good elbow flexors and wrist extensors;

(4) full passive ROM in shoulder, elbow and wrist; functional

ROM in the fingers and thumb; (5) absence of spasticity of

spasms in the elbow flexors; and (6) no more than minimal spas

ticity in the wrist or shoulder, providing it does not

interfere with

performance of ADL.

Psychosocial Criteria

Emotional readiness for surgery must be carefully evaluated.

The patient should have adjusted to his disability and have a real

istic understanding of the surgical procedure itself and the bene

fits to be derived. For example. in considering the BR to FPL

transfer, the patient must understand that he will not gain general

hand function, nor will hand function resemble that prior to in

jury. He will achieve active MP flexion of the thumb which is

functionally very significant. In considering the PD to TR trans

fer, the patient must understand that unilateral elbow extension

of fair-plus to good strength will not necessarily provide total

independence in ADL. In-depth interview and psychosocial eval

uation allow the therapist and patient to consider goals and realis

tic functional outcome together. It is helpful to have the patient

make a list of functional goals and activities he hopes to pursue

and achieve post-operatively. This allows the therapist to assess

how realistic the patient is with regard to his expectations of sur

gery. The long-term functional outcome of any surgery of this

type is affected considerably by actual use and challenge/The

patient who is lacking a definite post-operative plan with a realis

tic functional emphasis is probably not an ideal surgical candi

date. This information is available to the occupational therapist

following extensive evaluation and interaction with the patient,

and is critical for the surgeons to have in making the definitive

surgical decision.

There are several logistical factors which also must be consid

ered with regard to post-operative care. For the first three to four

weeks following surgery, the patient is in a long arm plaster cast

and careful upper extremity positioning is important. This limits

functional independence and the patient needs to have a plan for

meeting personal care and transportation needs. The discharge

setting and ability of family or caretakers to provide the increased

level of care must be clearly defined prior to surgery. This is

followed by a three to four week intensive rehabilitation program

generally done on an inpatient basis due to the need for four to

six hours of daily occupational therapy. Some patients are able to

manage reliable daily transportation and remain outpatients for

the intensive rehabilitation phase. The cast is removed three to

four weeks post-surgery and replaced by a carefully monitored

splinting program, requiring responsible follow through if the

patient is remaining at home during this part of the program.

Following the intensive rehabilitation phase of the program, the

patient continues to be restricted in many functional activities

(i.e., transfers, lower extremity dressing) for a total three month

post-operative period. This too requires careful explanation to

the patient and caretaker so that adequate assistance is provided

for the entire three months. The patient must also rearrange his

school or work schedule during the three month post-operative

period to accommodate therapy, outpatient clinic follow-up apVerran, Baumgarten, and Paris 165

pointments and the temporary functional limitations imposed by

the surgery. OCCUPATIONAL THERAPY POSTSURGICAL MANAGEMENT

Rehabilitation following a tendon transfer focuses on the fol

lowing areas: time, protection and support, ROM, skin care, re

education, therapeutic activities and ADL.

Time

The length of time between surgery and readmission for ther

apy varies depending on which surgery was performed. 3,4,5

Enough healing must have occurred to allow gentle active motion

of the transferred tendon. BR to FPL and BR to ECRB surgery

recipients are usually admitted three weeks post-surgery and PD

to TR recipients are admitted four to six weeks post-surgery. The

inpatient rehabilitation program is usually three to four weeks in

duration. Some patients may be able to complete their therapy on

an outpatient basis if they have good attendant care and demon

strate understanding of the restrictions and precautions. Patients

usually receive some inpatient treatment due to the ongoing com

plex needs of the spinal cord injured patient.

Protection and Support

Protection and support of the tendon transfer is achieved by

splinting and positioning. 2,4,5 The splint position is

graded accord

ing to the amount of stretch that is desired on the transferred

tendon and the amount of time that has passed since surgery. The

tendon is placed in a slackened position and is gradually

stretched by splinting and gentle active and passive ROM within

pain tolerance. Following the BR to ECRB transfer, the pro

tected position is 30° of wrist extension and 90° of elbow flexion.

Following the BR to FPL surgery, the slackened position would

place the elbow in 90° of flexion and the wrist in 30° of flexion. 3

The PD to TR procedure requires post-operative placement of the

upper extremity in full elbow extension and moderate shoulder

abduction, carefully avoiding horizontal abduction. 2 ∗ 5 A properly

fitted splint is necessary to avoid skin breakdown, especially

with decreased sensation in the upper extremities. At RLAMC it

has been found that a custom approach to splinting is necessary

to avoid skin complication. The occupational therapist is respon

sible for fabrication and fitting of thermoplastic splints used fol

lowing the BR to ECRB and BR to FPL surgeries. A hinged

elbow orthosis, manufactured by an orthotist, is used following

the PD to TR operation. Its fit and periodic adjustment are the

responsibility of the occupational therapist.

ROM

Increased ROM is achieved post-operatively by active and

gentle passive ranging. Excessive stretch to the transferred ten

don during active and passive ROM should be avoided. Both

origins and "new" insertions must be considered, as most of the

transferred tendons pass over multiple joints. Movement is grad

ually permitted away from the tendon's slackened position.

Three weeks following the BR to FPL surgery, thumb movement

is allowed only if the wrist and elbow both remain flexed. At four

weeks post-operatively the patient can extend the wrist if the el

bow remains flexed; or extend the elbow providing the wrist re

mains flexed. By the end of six weeks, maximum stretch of the

tendon transfer is permitted by allowing simultaneous extension

of the wrist and elbow. 8 Similar time guidelines apply in the

treatment of patients following BR to ECRB surgery with regard

to grading wrist flexion and elbow extension. 7 Following PD to

TR transfer, the patient is immobilized in full elbow extension

and flexion is increased ten to fifteen degrees per week following

four to six weeks of immobilization. These patients are main

tained in a long arm orthosis which blocks excessive elbow flex

ion at a preset angle and allows full extension. 9

Skin Care

The healed would area should be cleaned daily to encourage

sloughing of dead skin. 7,x,y The arm is bathed with warm water

and mineral oil to keep the skin clean and supple. The water 167

temperature must be set carefully due to decreased pain and tem

perature sensation. The occupational therapist must maintain the

appropriate arm position while performing this procedure to

avoid putting stress on the tendon transfer.

Reeducation

Reeducation of the transferred tendon may be accomplished

using various methods. Functional activity, isometric and active

exercise, biofeedback, and neuromuscular electrical stimulation

are some of the methods used to improve the functional out

come. 7-11 Prior to beginning a reeducation program, the patient

must be cleared by the physician to begin active exercise.

This

usually occurs in the third to fourth week post-operatively.

One of the most important factors in the selection of an activity

for reeducation is that it provides feedback to the patient. For

example, the occupational therapist can palpate for tendon glid

ing and give the patient feedback to enhance the quality of the

movement or contraction. Biofeedback units supply audio and

visual feedback to the patient when movement is performed cor

rectly and require minimal supervision by the occupational thera

pist. The intensity of the feedback may be decreased as the pa

tient becomes more proficient at isolating the desired movement.

Neuromuscular electrical stimulation gives the patient sensory

input as to what the contraction and movement should feel like.

Therapeutic Activity

Once the patient has achieved some active movement using the

transferred muscle, he may begin therapeutic activities which are

graded to increase endurance, coordination, and strength. Basic

activity analysis is used to grade activities to achieve the desired

goals. Care must be taken to combine the principles of

activity

analysis with post-surgical guidelines for protecting the transfer

red tendon. Size of the prehensile object must be carefully graded

so as not to overstretch the tendon transfer. In addition, resis

tance should be closely monitored until the 12th week post-surgi

cally. The occupational therapist needs to provide a balanced

program of dynamic and static activities. Dynamic activities

which require repetitive grasp and release may include mosaic

tiles, macrame, large beadwork or leisure games such as chess

and checkers. Static activities will focus on endurance building

and sustained tool use and can include painting, drawing, and

writing skills. All of the activities mentioned enhance coordina

tion and help to integrate the function of the transferred muscles.

These activities can all be graded to minimize resistance and

stretch to the tendon transfer. 7,8

Activities of Daily Living

As greater control, strength and endurance are achieved,

ADLs are incorporated into the program. Minor equipment adap

tation may be necessary to allow functional use of the extremity

early in the program. For example, following BR to ECRB sur

gery, a patient may use a WDWHO with an extension assist for

feeding. The extension assist will allow use and strengthening of

the wrist extensors and promote development of tenodesis. As

strength improves, the amount of extension assistance is de

creased. Leisure activity, desk skills, and light self-care activities

are used in the ADL portion of retraining. The patient is in

structed to continue upgrading his functional performance as the

tendon transfer becomes more solid, and thus more functional. 7,8,9

Outpatient Follow-up

Patients arc seen by the physician and the therapist in the out

patient clinic for evaluation of post-operative progress and prob

lems. Follow-up visits usually occur at two, four, and eight

weeks post-discharge. Resistive activities such as lower extrem

ity dressing and transfers may be initiated three months post

operatively. Clearance for all remaining ADL occurs at the same

time, including depression raises and wheelchair propulsion. SUMMARY

The three procedures described in this article potentially bene

fit many persons with quadriplegia secondary to spinal cord in

jury. Most likely to realize significant functional gain following

surgery is the quadriplegic population with injuries between C5 Verran t Baumgarten, and Paris 169

and C7. The BR to ECRB tendon transfer provides active wrist

extension and enhances tenodesis function, particularly if fol

lowed by the "key-grip" procedure. A dynamic pinch that is not

dependent on wrist position is achieved following transfer of the

BR to the FPL. The PD to TR transfer allows active elbow exten

sion and enhances stability and control of the upper extremity.

This can be done in conjunction with the distal tendon transfers

to further increase the force of prehension. The occupational

therapist plays an important role in identifying appropriate surgi

cal candidates, setting attainable post-surgical goals in collabora

tion with the patient, and in the administration of a functionally

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delphia: W.B. Saunders, 1986. Choosing the Components of an Occupational Therapy Work Assessment Program for a Psychiatric Hospital Antoinette Alleyne, BSc (OT), OT(C) SUMMARY. Guiding adult psychiatric patients back to competitive employment is a challenge to any occupational therapist. This paper describes how a work assessment program was developed for an adult population in a long-term psychiatric care center despite the lack of applicable models for doing so. The resulting "common sense" approach, a "how to" for those searching for programming guidelines, is presented with recommendations for

Antoinette Allcync at the time of writing was Assistant Director of Occupational

Therapy at Alberta Hospital Edmonton, Alberta, Canada. She was Supervisor in foren

sic psychiatry and developed the program described. She also served as clinical expert

in vocational rehabilitation for the national panel of consultants of the Canadian Associ

ation of Occupational Therapists.

The author acknowledges all members of the Occupational Therapy Department at

the hospital for their various roles in the development and evaluation of the program and

wishes to thank them for their continued efforts. 171 PRACTICE WATCH: THINGS TO THINK ABOUT the development of similar programs in Occupational Therapy Departments.

The Alberta Hospital Edmonton (A.H.E.) is a six hundred bed

psychiatric treatment center that offers long-term care, including

a full range of occupational therapy services to the full spectrum

of psychiatric diagnostic categories although schizophrenic

ill

nesses predominate. Patients are eighteen years and over except

eighteen adolescents at the hospital for assessment and treatment

under the Young Offenders Act. The adolescent unit is part of the

forensic psychiatric assessment and treatment service for patients

who have offended against the criminal code and are alleged to

be suffering from a mental illness.

The Occupational Therapy Department provides vocational

services at the hospital and in the past has offered "situational

assessments" and work adjustment training using activity groups

and workshops within the hospital. 1.2 Over the past five years

these services have been supplemented and now include stan

dardized tests and work sample approaches to evaluation of work

aptitude and ability. In its decisions about patients the program

also uses information and services provided by a multidiscipli

nary approach to rehabilitation 3,4 that includes extensive psycho

logical, medical and nursing support as well as social work ser

vices, remedial and adult education.

Vocational rehabilitation literature 5,6,7,8 report that a

range of

services and strategies may be used to prepare persons with spe

cial needs for the employment market. These services may in

clude:

1. Psychological testing, most often in the areas of intelligence, aptitude and personality.

2. Interest screening using audiovisual methods and interviews.

3. The use of commercial job samples for evaluating aptitudes and abilities.

4. Workshops for training specific job skills and adjustment to work.

5. On-the-job evaluation at sites within a treatment facility e.g., laundries, food service departments and laboratories.

6. Vocational counselling and placement. Antoinette Alleyne 173

7. Referral and follow-up at community based training facilities.

8. Job "try-out" or placement in competitive employment with support and follow-up.

These elements may be combined in a variety of ways in an

occupational therapy program to assess patients and their specific

needs for work adjustment and training. 9,10

Psychiatric patients, upon leaving the hospital, often enter the

labour force joining the unemployed, underemployed and disad

vantaged workers because of residual psychiatric disabilities.

These disabilities are mainly in the areas of motivation

and drive,

decreased cognitive or intellectual ability, lack of confidence and

social skills. Their difficult situation is compounded by a general

lack of economic and social resources, poor work history and

lack of career continuity due to repeated episodes of illness.

At A.H.E. careful screening of potential components of the

work assessment program in occupational therapy required spe

cial attention to the needs of psychiatric patients. The result of

efforts to find a solution is a program particularly suited to the

needs of our patients in overcoming barriers to reentry into the

work force and increasing their survival in the face of the stress

of return to competitive employment after major psychiatric ill

ness. A description of the components of the program follows,

not necessarily in the order that they are applied to any given

patient but one that suggests a logical progression that might be

followed. PROGRAM COMPONENTS

Situational Assessment

A situational assessment approach is used to observe patient

behaviors and skills in a "normal" rather than test situation. It

involves assignment to a variety of workshops within the occupa

tional therapy department where patients engage in printing,

woodworking, the production of ceramics and other small manu

facturing. It is often the first step in the evaluation and change

process. An initial assessment forms the basis of gradual behav

ior shaping achieved by placing increased demands for more

adaptive behaviors on the part of the patient when maladaptive

behaviors are identified. The workshop supervisor observes and

rates specific work attitudes and behaviors in order to give feed

back to the patient. The patient receives an incentive payment

based on his work performance rating which further reinforces

the work atmosphere and the demands of a job rather than a test

situation. The stress of a work situation exists but support and

comraderie is available. The workshop is viewed by the patient

as a meaningful situation, and motivation is enhanced by the pro

duction of some service or a product for sale or use.

Vocational Assessment

Work samples from several of the commercially available

evaluation systems 11 have been combined to provide a range of

measurements that suit the hospital patient group who have

worked (or may choose to) in trade occupations. The Singer Vo

cational Evaluation System and Valpar Component Sample Sys

tem have provided a comprehensive range of tools for measuring

task specific abilities and aptitudes. This information is used in

planning training programs for individual patients.

The patient's level of function, skills, aptitudes, work habits

and social interactions are compared with observations of per

sons in actual training or career positions. Because this type of

assessment is standardized it is a more accurate predictor of read

iness for employment than a situational assessment. Occupa

tional therapists are skilled in observation of behaviors, compari

son with norms and task analysis; 1 the samples therefore add to

these dimensions by presenting tasks, situations and work chal

lenges identified as integral to specific occupational areas as well

as providing a standardized format and norms for the various

occupational groups.

Work Placement

At sites within the hospital campus patients may be assigned to

work under the supervision of job site personnel rather than occu

pational therapists. For some patients these assignments are their

first "real work" experiences and are useful approximations of

the demands of competitive employment. Jobs such as those in 175

the laundry, medical laboratories and hairdressing now provide

this intermediate level of work readiness training. The major

benefit to the patient is the gradual weaning away from the sup

portive workshop atmosphere to a more demanding "real work"

situation.

A number of placements have been developed each with a job

description and designated site supervisor. The therapist guides

the patient's choice from those approved work placements. Once

the patient is placed, regular follow-up visits are made to provide

support for the patient and consultation to the site personnel. The

therapist is available to the site personnel as a "resource" in

managing aberrant behavior and in identifying appropriate meth

ods of supervision and feedback to the patient, the therapist's

unique supportive role is based on knowledge of the patient

and

clinical skills particularly fitted to the needs of a psychiatric pop

ulation.

Vocational Counselling

The aim of the vocational counselling component is to help

patients acquire and integrate the skills necessary to stay on a job;

therefore all information and resources are brought together to

increase this likelihood. The results of all occupational therapy

assessments, including activities of daily living assessments,

work situational assessments and standardized vocational assess

ments, are combined in a report that summarizes overall perfor

mance, as observations of proficiency and worker traits together

with recommendations to both the patient and the treatment team

or follow-up agency personnel. The work rehabilitation program

that is drawn up for the patient addresses the specific needs iden

tified in the report. The report also provides the framework for

counselling the patient at weekly group meetings held in conjunc

tion with his work training experience. 12 Counselling takes the

form of individual or group exercises. Role playing, verbal

groups, films, written exercises or readings are some of the

methods that are used. They deal with aspects of human rela

tions, self concept, effective communication and acceptable be

haviors related to survival on a job. 13,14 The counselling process

also involves practice of skills such as job search techniques,

resume writing and career exploration. An educational approach

using a didactic style has been found to be most successful, a

finding that was reported by Barter and his associates in treating

patients with chronic psychiatric problems who were involved in

the transitional employment service of the Community Interac

tion Program in Sacramento, California. 15

The didactic style provides a structure that helps the patients to

focus on gathering information; it also allows the therapist a wide

scope in methods of transmitting information and facilitates inte

gration of that information through active patient participation.

The therapist is also a credible and influential catylist for change

due to the many areas and stages of involvement with the patient

along the entire course of readying for work, from first

involve

ment in basic activity groups to actual job interviews and then

going out to work in the community.

Community Outreach

Assuming continuity of the total vocational effort after dis

charge is a most crucial step if patients really are to succeed. In the

program at A.H.E., lack of adequate resources for follow-up is a

weakness. Community outreach is provided only on an ad hoc

basis by hospital personnel; they do whatever is possible within

the constraints of their inpatient care responsibilities or by refer

ral to community agencies. Industrial training facilities, sheltered

workshops, government manpower agencies and sympathetic

employers in the private sector are our valuable resources in plac

ing patients in employment situations. However, when our pa

tients' fail on the job, it is often due to an emotional crisis and

relapse that could be managed best by someone familiar with the

patient and his psychiatric problems. Appropriate and timely in

tervention in emotional crisis often avoids failure on the job and

return to hospital. SELECTING PROGRAM COMPONENTS

No combination of program components could ever be de

scribed as ideal in meeting all the needs of adult psychiatric pa

tients. Each facility has to find its unique combination of meth

ods, devices, tests, observation tools and training systems related

to the needs of the patients they serve. The following general 177

suggestions have been found to be useful guides in decision mak

ing. These "common sense" suggestions have resulted from the

trial and error experiences in meeting the challenge of developing

an effective work assessment program for the adult psychiatric

population at A.H.E.

The first factor to consider in planning any program is the

nature of the needs of the patient population, individually and

collectively. What are their special needs, deficits, disabilities or

difficulties? Do types of problems or barriers dictate particular

style, method or approaches? For our psychiatric population the

most evident problem is the instability of the patients' mental

status.

In dealing with psychiatric disturbances the assessment of a

problem and the patient's method of coping are frequently unsta

ble and call for sustained support, evaluation and reevaluation to

ensure timely change or intervention.

In addition, for patients to engage in some evaluation, training

or job, they must have certain minimal prerequisite skills or lev

els of function. Frequently a specific reading level, educational

grade, intelligence within a certain range, particular degree of

manipulative skill, strength or problem solving ability may be

stipulated. One must determine whether these prerequisites are

likely to be attained or are within the capacity of the patients to be

served.

Investigation of the commercially available and standardized

systems or tests, if you opt for these, will reveal if they are de

signed to match the needs of your particular patient group and

their range of skills and abilities. You will find that some evalua

tion techniques fit your population better than others depending

on the group for whom they have been developed. A description

of the groups may provide information on age, sex, diagnostic

educational, sociological and occupational factors that would in

dicate its suitability to any given population.

The second factor to influence your decision making is the

extent of available resources in terms of budget, space, already

existing equipment that could be converted to this use, other ser

vices that could contribute, personnel available for assignment to

a program and their existing skills and training needs. Resources

must be assessed at the same time one considers patient needs,

types of evaluation/training they may require, as well as the goals

of any program that is established. All are inevitably tied to

gether. One cannot decide needs or program goals in the absence

of reality about resources. Use of paper and pencil tests for work

skill evaluation simply does not substitute for actual work experi

ence. If space and dollars are not available for actual work trials,

perhaps a program should not be contemplated.

Third, in planning, the purpose and scope of the program must

be clearly defined. Is the aim to simply supply patients with ca

reer information and help them choose possible career or training

tracks? Or, do you want to reassure and motivate by

providing

hands-on experiences to which patients can relate? Perhaps the

aim is to accurately compare a patient's present skills, aptitudes

and level of functioning to specific norms? The problems of psy

chiatric patients are often interactional and behavioral com

pounded by lack or disuse of specific usable skills. One must

identify the types of information required for training and ulti

mate placement of patients in a program.

Fourth, once goals and general design is settled, it is essential

to carefully construct and develop the relationship between the

community and the facility if successful resettlement of the pa

tient is to occur. Only if types of jobs available and educational

or training opportunities are known can one realistically decide

on the precise types and ranges of evaluations to be included in

the assessment program. Thus patient need, program goals and

available resources, both in and outside of the hospital, must be

matched realistically with job opportunities. Only then can a pro

gram hope to be successful in preparing patients for work roles. KEY QUESTIONS

The question of whether commercial samples or evaluation

systems will suit the needs of the patient group always arises.

The answer is not easily arrived at but the following are factors to

be examined before selecting a program configuration. If avail

able tools/samples match job/training opportunities in your area

and the resources are there to purchase and use them, then deci

sions are made more easy. The questions most frequently asked

are:

Why Purchase a Commercial System?

Fcibleman, J K: (1954) Theory of Integrative Levels.
British Journal for the Philosophy of Science, 5, 59-66

Reilly, M: (1974) Play As Exploratory learning. Sage,
Beverly Hills

CHILDREN WITH SPINA BIFIDA, EARLY INTERVENTION

AND PRESCHOOL PROGRAMMING, G. Gordon William

son, PhD, OTR, Editor. Paul H. Brookes Publishing Co., Post

Office Box 10624, Baltimore, MD 21285-0624, 1987, 231

pages, $23.95. This book addresses all of the major areas
of concern for the

care of children with spina bifida from infancy through pre

school. It presents material from all of the disciplines
most likely

to be involved with this population. It is written in a
cohesive

style that is particularly impressive considering the
number and

diversity of contributing authors. It begins with a
chapter on Children with Spina Bifida and

Their Families. While the information is not new it is
certainly

good basic information. It sets the tone for the book which
places

a very nice emphasis on considering each person as an
individual

and looking at assets instead of focusing solely on
problems. It

also discusses the concepts of "learned helplessness" and
cau

tions readers not to turn anyone into a "good patient."
This is,

indeed, a critical point to be clearly established for people who

work with this population. The subsequent chapters deal more specifically with the myr

iad of functional problems and clinical systems that may be en

countered by people with spina bifida. They provide an overview

of such topics as sensorimotor assessment and intervention, posi

tioning and mobility, perceptual-motor performance, speech and

language, and activities of daily living. The different chapters

present materials on assessment and treatment intervention strat

egies with varying degrees of depth and specificity. The reader is

able, in some cases, to discern the particular frame of reference

of an author. This text would be ideal for the professional new to working

with people with spina bifida or those with limited experience as

it provides a broad overview of related issues. Its value for stu

dents and even for parents is mentioned in the preface and they

would indeed find it helpful. The language level is easily under

stood by parents as well as professionals. Either lay terminology

is used or definitions of the medical terms are provided in

a glos191

sary in Appendix C. Clinicians with more experience would want

to delve more deeply into their own areas of expertise and ex

the best resources on the subject and thus provide readers with

many choices for further pursuit of the subject. Elizabeth Wyckoff, OTR Pediatric Supervisor Rancho Los Amigos Medical Center Downey, CA

PHYSICAL MANAGEMENT OF MULTIPLE HANDICAPS,

Beverly A. Fraser, Robert N. Hensinger, and Judith A. Phelps.

Paul H. Brookes Publishing Company, Post Office Box 10624,

Baltimore, MD 21285, 1987, 277 pages, $24.95. This book is an excellent reference for any therapist working

in the areas of the multiply handicapped. It was written by a team

composed of an occupational therapist, orthopedist, and physical

therapist with specific chapters by a hand surgeon, an occupa

tional therapist involved in seating systems and an orthotist. This

team approach lends itself well to the subject matter since coordi

nation of care is extremely important with this population. This

revision of the text, originally published in 1983, is welcome

today as an increasing number of those severely involved babies

are being saved by high technology and will subsequently

need

therapy services for their entire lifetimes. It represents a compila

tion of information from many of the individual discipline's text

books, journal articles, and obviously from much personal and in

depth experience on the part of the professionals involved. The

first few chapters are general in nature, aimed at the new practi

tioner or the therapist who deals only occasionally with these

children. The real substance of the text follows with sections on

orthopedic management of the spine, lower extremities and up

per extremities; seating systems and orthotics; positioning and

adaptive equipment. The section on orthopedic management is explicit with pic

tures and x-rays to graphically illustrate the deformities often

seen. Common surgeries are presented in a readable manner with

the usual justification for the procedures briefly stated. Of partic

ular interest to the occupational therapist would be the section on

hand surgeries. The author states that although goals for hand

surgery for this population are limited, that there are several ap

propriate objectives. Among these are cosmesis that allows

the

individual to appreciate a more normal posture, facilitation of the

use of a communication board, facilitation of dressing, and elim

ination of hygiene problems. The seating section is well done as far as the principles of

seating and the seating products presented. However, those

stressed were primarily those which were obviously well known

to the author and represented a fairly limited geographical area.

The information was fortunately presented in broad enough terms

so that the experienced therapist could easily adapt the informa

tion presented to what is available or commonly used in her area.

The orthotics chapter has an interesting overview of the history

of orthotics and a good review of the frequently used orthotic

devises, again with good pictoral illustrations. The section on adaptive equipment for daily living also had

some excellent pictures. However, this reviewer found several

items/positions described without illustrations where they would

have been useful. The section on positioning, especially with the

lower extremity, again used some fairly regional equipment but

again the principles and system construction could be

duplicated.

The chapter on upper extremity positioning is a must for any

occupational therapist working with these children. The pictures

of commonly seen postures and deformities were excellent illus

trations that clearly showed many of the problems seen daily by

this reviewer in actual practice. The splinting guidelines were

well thought out and appropriate to the goals for this specific

population. The brief discussion of motivating these multiply

handicapped children to utilize their available hand skills was

very pertinent. The appendix listings of adapted switches and Book Reviews 193

motivational toys alone is worth the cost of the book to any occu

pational therapist truly interested in helping these children attain

their highest levels of skill, Betty Snow, MA, OTR OT Educational Coordinator California Children's Services Los Angeles, CA

EDUCATING CHILDREN WITH MULTIPLE DISABILITIES:

A TRANSDISCIPLINARY APPROACH. Fred P. Orelove and

Dick Sobsey. Paul H. Brooks Publishing Company, Post Office

Box 10624, Baltimore, MD 21286, 1987, 367 pages, $26.95. This book provides the reader with a clear and indepth descrip

tion of the transdisciplinary model, a team decision-making ap

proach. It is presented along with several other team approaches

and describes the advantages and disadvantages of each system.

The needs of children with multiple disabilities are presented and

the authors describe how this united service delivery system pro

vides the expertise and diverse skills from many specialized

fields, needed to educate these children in an effective way. Basic descriptions of normal and atypical motor development

are presented for all team members to understand. Handling and

positioning techniques, and side effects of medications are ade

quately covered. Further chapters present curriculum and instruc

tional programming, developing instructional adaptations, com

munication and activities of daily living skills, and work with

families. The authors stress the importance of providing opportunity for

function at some level meaningful to the child in his daily en

gagement in the social and emotional areas and they present a

practical array of techniques useful toward developing this type

of fulfillment. New and current educational theories are presented in a clear

and readable manner. This is a good reference text for the

school

based occupational therapist working with the transdisciplinary

approach and for the therapist entering the school system for the

first time. For the experienced therapist, it provides a reference

text useful for building relationships with all other team members

including the parent. Barbara T. Engel, MEd, OTR Private Practice Pasadena, CA

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Dexterity as a Valid Measure of Hand Function: A Pilot Study

Françoise Poirier, BA, OT(C), PT, MBA

Doctor in Ergonomics

SUMMARY. The evaluation of dexterity as a measure of hand function requires caution. The results of this pilot study demonstrate the importance of defining dexterity, of considering work strategies and of analyzing the work station before planning a hand rehabilitation program and a return to work.

In many industries, as part of a procedure to select qualified workers, the evaluation of dexterity is considered a good indication of the worker's manual potential. In many rehabilitation settings, dexterity evaluation is also regularly used as a valid indication of the residual function of the hand, as well as a method of measuring improvement or deterioration of hand function. It should be emphasized that the primary goal of a rehabilitation program is always to return a client to the community, the ultimate goal for a worker being a return to the former work station. Every occupational therapist will agree to this principle.

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The author wishes to thank Mrs. Pamela Harris Gauvin, OT(C), Head Occupational Therapist, Hopital de l'Enfant-Jesus, Quebec, Canada, and Professor Elizabeth Dutil, Ecole de Réadaptation, University of Montreal, Montreal, Canada, for their assistance in the preparation of this paper.

For industrial or therapeutic purposes, dexterity is evaluated with various tests that are adopted for their flexibility and reliability. Unfortunately, though, the validity of these tests is not a factor in their selection. As it can be considered that industrial purposes are the opposite of therapeutic goals, we must realize that the principle behind using the same test in both situations may be questionable. Indeed, in the latter situation a client is competing with himself, whereas in the former situation a worker is coping with a production demand. It must be added that most tests known to occupational therapists have been developed in a very controlled situation, using ordinary equipment in a daily task such as handling a fork or a teapot, and standardized on a population recovering from illness or with a handicap, who are in fact resuming a lower performance activity without a production demand. The focus of this study is on the manual strategies observed in a real work situation requiring dynamic as well as uncontrolled high production tasks in which the worker is performing with heavy equipment. The difference between the two situations suggests a repeated need for modified movement patterns that must be taken into consideration in any evaluation.

Four tests that are used in either an industrial or a clinical setting have been studied: the Minnesota Rate of Manipulation Test,[1] the Purdue Pegboard Test,[2] the Sister Kenny Test,[3] and the Stromberg Test.[4] They are very widely used as aids to personnel selection in industrial settings; they are also used in therapeutic settings as a means of evaluating the potential hand function of patients. On the other hand, many therapists who are familiar with these standardized tests often use other "homemade tests" which they find better suited to their needs. However, there is no guarantee that results obtained from either the standardized or the "homemade" tests will have any scientific value, as their validity is questionable for the reason explained previously.

One must explore the dimensions of the word dexterity and its impact in an industrial or a therapeutic milieu. One must ask why dexterity is measured. Is it to evaluate the quality of fine movements? Is it to measure agility, which is a combination of precision and speed, rather than strength alone? When evaluating dexterity, can one assume that the results are an indication of the potential function of the hand, regardless of the specific setting

where the client has to perform? What is measured exactly? In order to answer these questions and understand dexterity in all its dimensions, one must first define dexterity and then identify its components.

DEXTERITY DEFINED

Few authors have defined dexterity. Does it include range of motion, strength, tolerance to static effort, tolerance to dynamic effort, and speed of gross or fine movements? Does dexterity refer to only one of these parameters or to all of them? And what about the hand strategies requiring movement patterns, muscular responses in relation to different types of prehension, for example that of Lansmeer[5] and Backhouse?[6] However, there has been very little research on the same phenomena on the worker's hand while performing heavy tasks in a real work situation instead of in a laboratory.

In their search for an appropriate test for use in vocational evaluation, Tiffin in 1947,[7] Tiffin with Asher in 1948,[8] and Fleishman and Hempel,[9] divided hand movements into gross and fine, when referring to task demands. Furthermore, they dissociated ability and skill, considering ability a result of learning and physical development. Dexterity includes many factors that contribute to individual variations in manipulative skills. Skill emerges at a more refined level of performance. Consequently, development of skill depends on one's previous level of ability. More recently, Tubiana[10] has recognized many functions of the hand, explaining their characteristics from the point of view of anatomical structure. With Harrison,[10] he has linked dexterity to movement, attributing this ability to rapid coordination of voluntary movements, acquired through memory, learning, training and experience. And finally, Carter and his associates[11] consider that dexterity is a "distinctively human characteristic," and presume that it is "an enduring characteristic of an individual which can be measured repeatedly." Based on these findings, it is proposed that dexterity be defined as "MANUAL ABILITY THAT REQUIRES RAPID COORDINATION OF GROSS OR FINE VOLUNTARY MOVEMENTS, BASED ON A CERTAIN

NUMBER OF CAPACITIES, WHICH ARE DEVELOPED THROUGH LEARNING, TRAINING AND EXPERIENCE."

A TWO CASE EXPLORATORY STUDY

In order to study the voluntary hand movements involved in a work situation, an exploratory observation was conducted of the manual strategies of two workers employed in heavy work, in the manufacturing of wood products.[12] Attention was focused on the different types of grip used on the job. For data collection, hand movements were classified into three categories: palmer grip, digital grip, and pressure.

Palmar grips, also called gross grips,[13] include all grips that involve the contact of the palm with the object, and always result from the combined action of the palm and one or several fingers. These grips are mainly used for gripping large objects.

Digital grips exclude the palm and result from the combined action of the thumb and one or several fingers. The index, or the medius, and the thumb are most often required and only the distal joints are involved. These are called fine or precision grips and are used for gripping small objects. Taking nailing as an example, a palmar grip is used to hold the hammer and a digital grip to hold the nail.

Finally, pressure is applied with the palm and/or with the fingers to stabilize the work. The term "pressure" is used when a unidirectional force is applied to an object by the hand. This force may be light or heavy and applied by the whole hand or by only part of it.

Methodology

Two male carpenters, aged 59 years and 26 years, were selected at random from wood product factories for the study. Worker "Y" was considered as right handed and worker "Z" was left handed, the laterality being determined by the hand holding the hammer. They were observed continuously for periods of 55 and 60 minutes respectively while performing carpentry

*Results of this research were presented in part at the 1984 International Conference on Occupational Ergonomics in Toronto, Canada.

tasks such as nailing, sawing, measuring, etc. This observation period was considered by the workers as a typical uninterrupted work session.

Each worker was observed simultaneously by three persons. One person observed the right hand, another the left hand. The third person recorded the activity being performed, and coordinated the three observers with a stop watch. A specially designed observation grid was used to record data on the types of activity performed and their duration (Table 1).

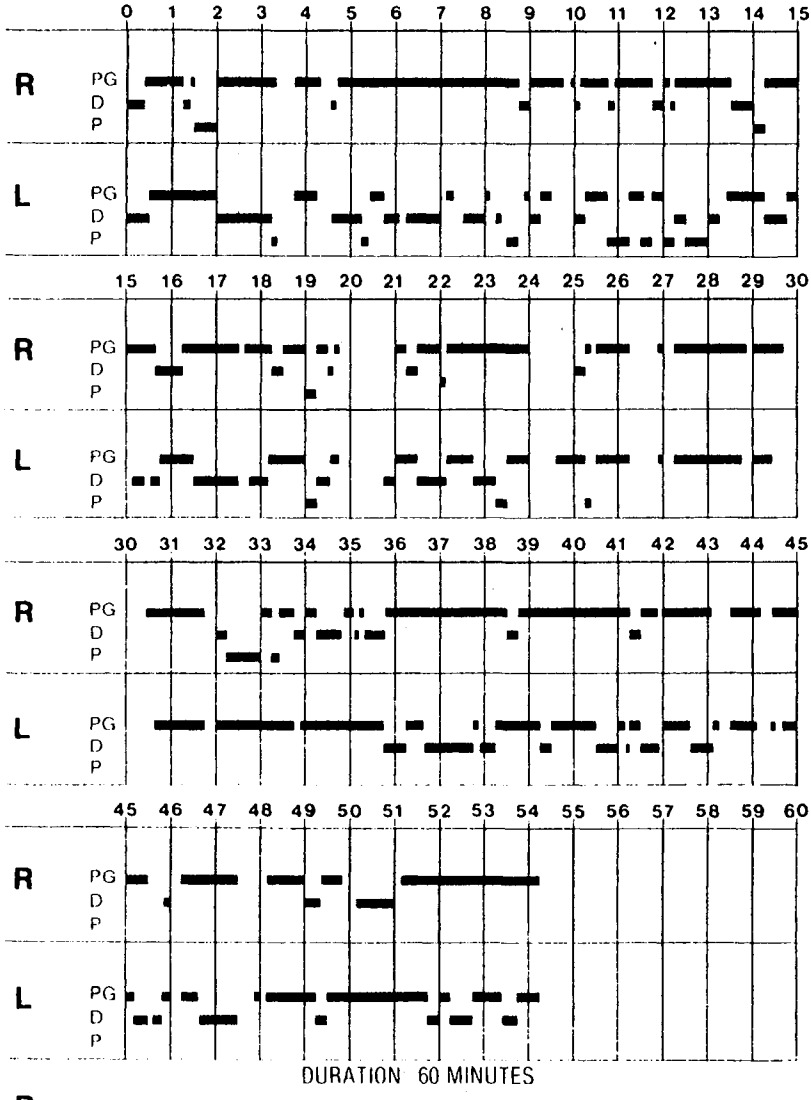
Figures 1 and 2 contain data pertaining to the right-handed worker; Figures 3 and 4 contain data pertaining to the left-handed worker. Figures 1 and 4 give the duration of each type of grip and pressure for the dominant hand, and the pattern of their use in a 55 or 60 minute period. Empty spaces indicate periods of relaxation and strategic planning for the next movements. The importance of the palmar grip was noted; evidently it is the one most often used by the dominant right hand for worker "Y" and by the dominant left hand for worker "Z." This grip also has to sustain effort for a longer duration on the dominant side (uninterrupted duration) as opposed to the non-dominant side. Alternately, digital grips were used more extensively by the non-dominant hand than by the dominant one (20% vs. 15% for worker "Y," Figure 5, and 27% vs. 20% for worker "Z," Figure 6). These grips are characterized by greater sustained effort on the non-dominant side (Figures 1 vs. 3 and 2 vs. 4).

Data for the non-dominant hand (Figures 2 and 3) show that the palmar grip is used less often than by the dominant hand, while the digital grip is used more often. In addition there is a different pattern for the dominant and non-dominant hands. Comparing Figures 1 and 2 to Figures 3 and 4, it is interesting to note the "mirror effect" resulting from dominance: palmar grip is used more extensively on the dominant side, and digital grip on the non-dominant side.

Finally, the data show that pressure was applied more sporadically than the grips and was prominent on the non-dominant side (Figures 1 to 4).

From this preliminary study, the following deductions can be made:

Table 1: Data grid. Duration of grips for a 55 minute period (worker "Y")



R:RIGHT
L:LEFT PG:PALMAR GRIP D:DIGITAL GRIP P:PRESSURE :15 SECONDS

Fig. 1 WORKER "Y", RIGHT HANDED, GRIPS AND PRESSURE /DURATION (RIGHT HAND)

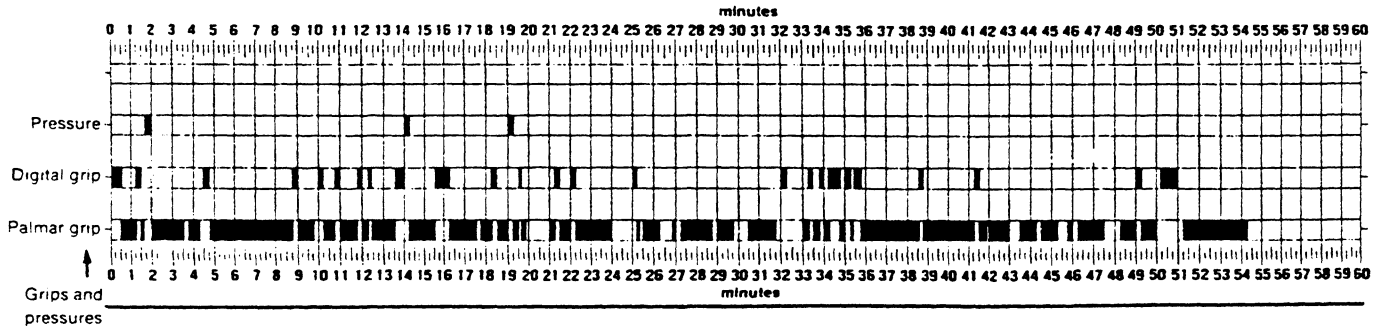


Fig. 2 WORKER "Y", RIGHT HANDED, GRIPS AND PRESSURE /DURATION (LEFT HAND)

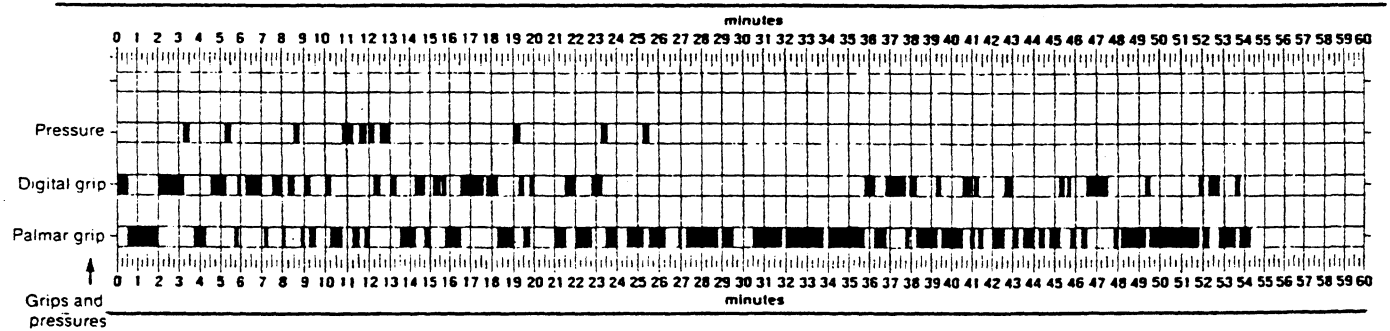


Fig. 3 WORKER "Z", LEFT HANDED, GRIPS AND PRESSURE /DURATION (RIGHT HAND)

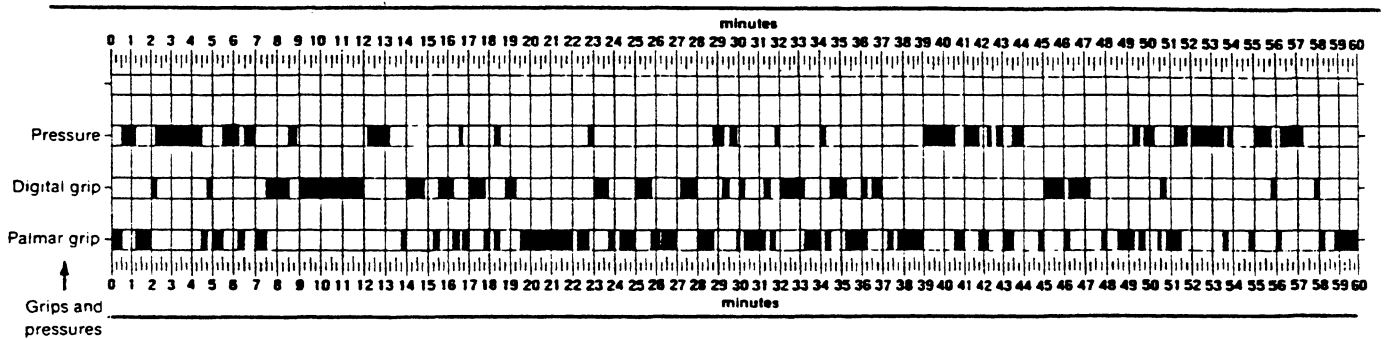


Fig. 4 WORKER "Z", LEFT HANDED, GRIPS AND PRESSURE /DURATION (LEFT HAND)

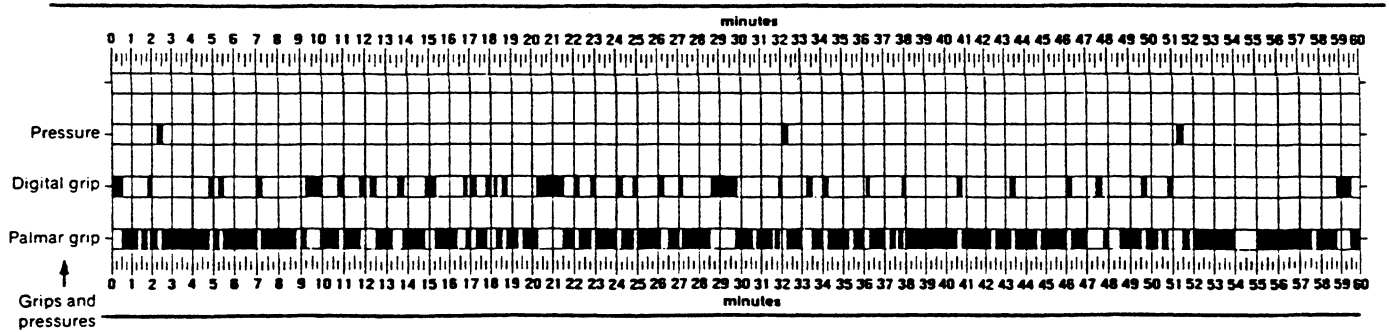


Fig. 5: Grip and pressure duration in percentage, worker "Y" for a 55 minute period

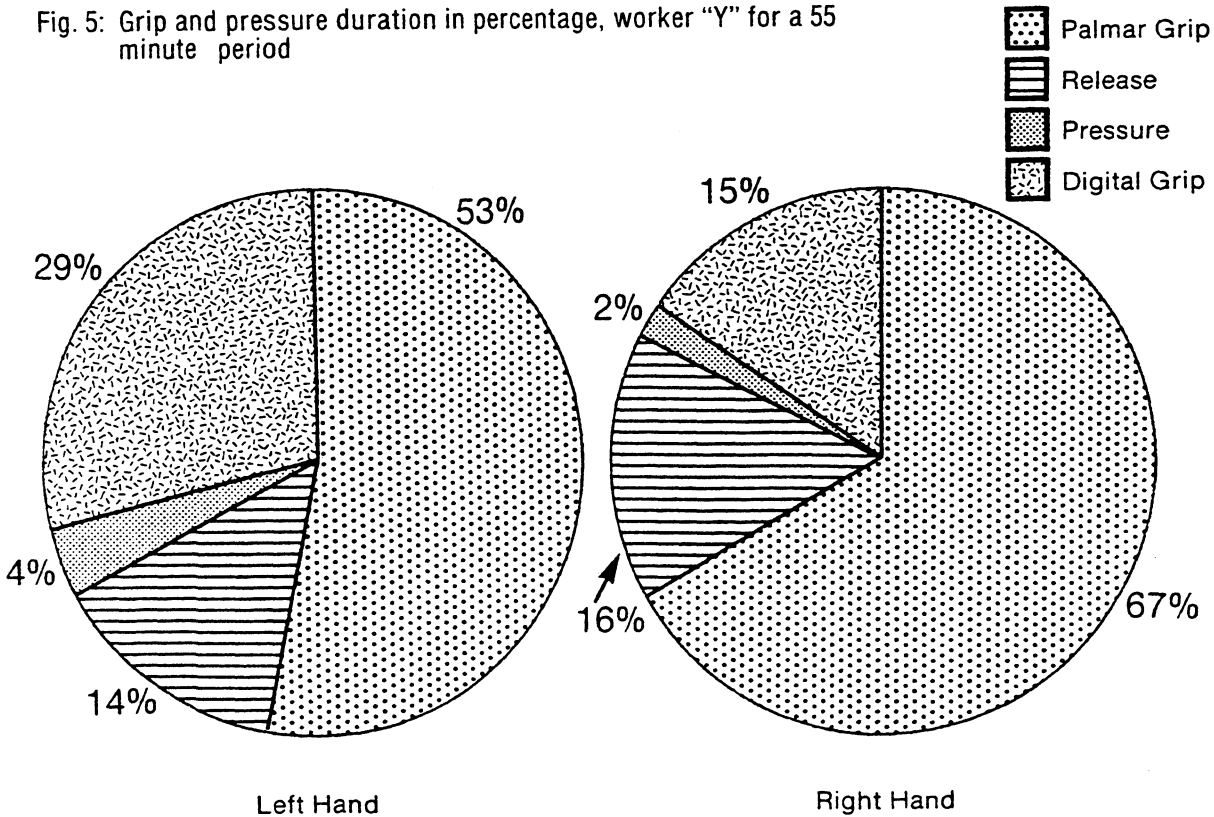
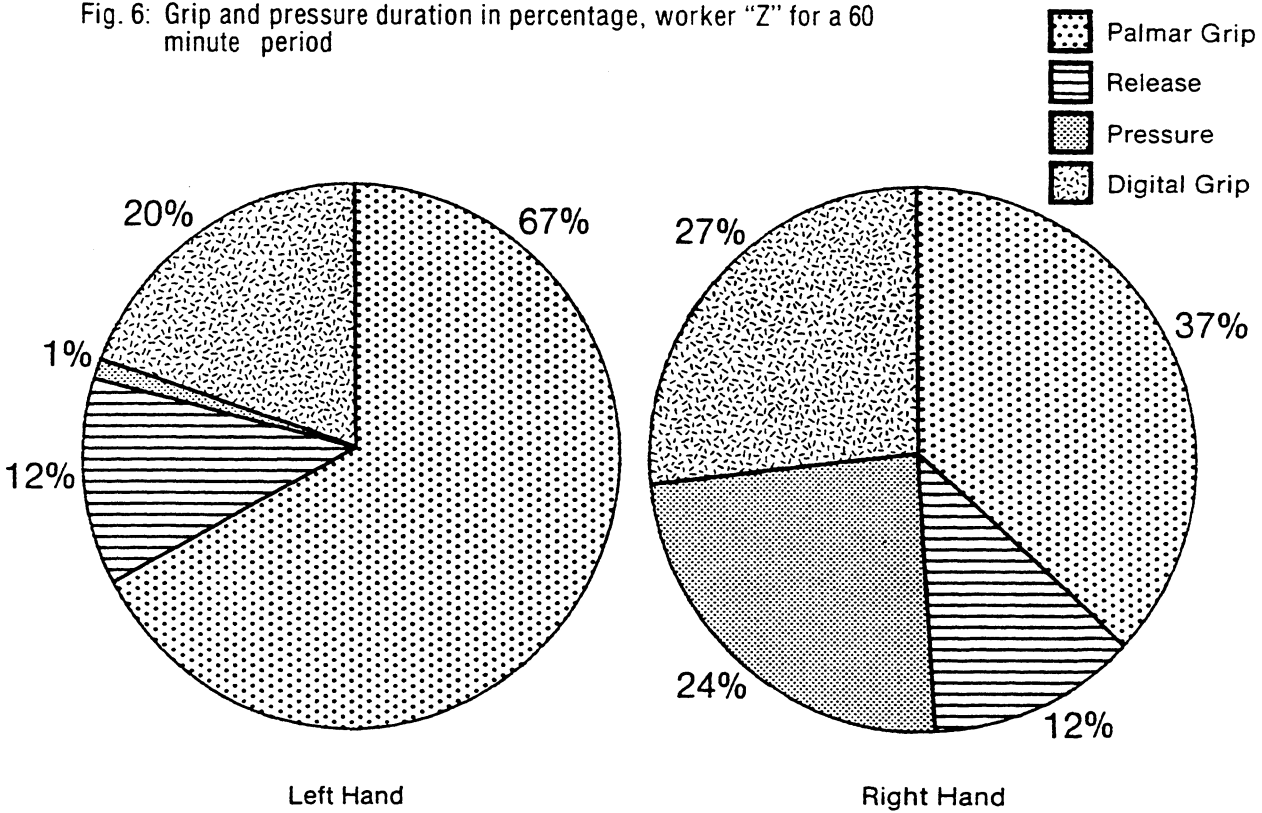


Fig. 6: Grip and pressure duration in percentage, worker "Z" for a 60 minute period



- workers adopt work strategies according to task demands which vary from one hand to the other, as far as finger movement, strength, pattern of use and other parameters are concerned;
- the work strategies observed for each hand show a typical motor pattern: static movement for the dominant hand and dynamic movement for the non-dominant hand;
- the palmar grip is more predominantly used by the dominant hand because of the need for a higher tolerance to static effort;
- the digital grip is more predominantly used by the non-dominant hand due to the need for quick, dynamic, and light effort.

Consequently, tests used to evaluate dexterity as a way of measuring the degree of recuperation accomplished by the client, or his potential to return to his former job, must correlate with work strategies characteristic of the dominant and the non-dominant hand.

FOUR COMMONLY USED TESTS

With these findings in mind, four dexterity tests were analyzed in terms of the type of grip which they require: the Minnesota Rate of Manipulation Test,[1] the Purdue Pegboard Test,[2] the Sister Kenny Test,[3] and the Stromberg Test.[4] These tests were selected because they are used in either an industrial or a therapeutic setting.

Table 2 shows that for all four tests, the activities performed required a digital grip: a tri-digital grip for two of them, and a bi-digital grip for the two others. None of the activities tested required a palmar grip. However, according to the findings of this study, the work strategies of workers employed in heavy work reveal a more extensive use of the palmar grip by the dominant hand, while the digital grip is more prevalent on the non-dominant side. Therefore, it can be concluded that the above tests are valid only for assessing the non-dominant hand.

Consequently, pre-vocational hand assessment must be undertaken with caution and the relation between the grips tested and the work strategies required by the patient's activity must be checked. If his work requires a palmar grip, the rehabilitation program must be planned accordingly, otherwise the appropriate therapy of the client's dominant hand may not be undertaken.

DISCUSSION

"Grips" are essential in heavy work.[14] Singleton[15] agrees with Fleishman[9] in dividing a task into components such as speed of limb movement, wrist-finger speed, finger dexterity, manual dexterity, arm-hand steadiness, control precision, and so on. Prehension is one of the most important functions of the hand, and refers to use of grip (palmar or digital). Furthermore prehension implies that "holding" is a function of gripping. From this study it can be stated that the hand is holding most of the time, which leads one to expect fatigue and to suppose that "hand release" is practiced to give the muscles the necessary rest. Indeed, Figures 5 and 6 show that palmar grip is the grip most frequently made by both hands, however predominantly by the dominant hand. Digi-

Table 2. TYPE OF GRIP MADE IN FOUR DIFFERENT TESTS

GRIP MADE / TEST	PALMAR	DIGITAL
MINNESOTA RATE OF MANIPULATION TEST(1)	-	TRI-DIGITAL
PURDUE PEGBOARD TEST(2)	-	BI-DIGITAL
SISTER KENNY TEST(3)	-	BI-DIGITAL
STROMBERG TEST(4)	-	TRI-DIGITAL

tal grip is less frequent, although its relative predominance is noted for the non-dominant hand. In the tasks observed, which were part of heavy work, the grip made to "hold" usually involved the entire hand rather than the tips of the fingers.

The method of determining dominance may be considered unconventional when compared to methods which would be required in a laboratory setting. However, it must be realized that a study conducted in an industrial setting must conform to limitations imposed by the situation, such as production schedules. This did not allow an interruption of production necessary for a more precise analysis of dominance. Conducting research in a natural industrial setting necessitates a quick but unconventional method of classifying data. Therefore, the word "dominance" must be understood as referring to the hand controlling the tool.

The number of subjects studied was limited to two. The results cannot therefore be statistically significative of phenomena that could be observed in a large population. Nevertheless, they must generate attention on the part of the therapist when planning a rehabilitation program because of their impact and serious consequences on reinsertion in the workplace. These findings should be taken into consideration when adopting a method for evaluating dexterity, and the method's validity in determining potential hand function for a specific task should be questioned. Tests currently used for evaluating dexterity, such as the Purdue Pegboard Test,[16] and the Minnesota Rate of Manipulation Test,[1] refer to fine or digital dexterity only. Consequently, caution is needed when using these tests to select personnel, as already pointed out by Fleishman and Hempel.[9] It should be emphasized that it is essential to assess the validity of tests with both industrial and clinical applications.

Therapists must therefore be very specific when selecting a test to evaluate a patient's dexterity as part of a pre-vocational assessment. The following procedure should be considered:

- carry out a preliminary analysis of the client's work station;
- evaluate the type of dexterity needed in task performance and differentiate between that required by the dominant and non-dominant hands;
- choose an appropriate test accordingly.

CONCLUSION

This pilot study is descriptive and exploratory. Therefore, results cannot lead to any conclusion that could be statistically significative; more observations on a larger population are necessary to identify constant phenomena. In spite of this limitation, the results warrant immediate communication because of their importance in occupational therapy program planning. Further research shall certainly focus on these same phenomena on a larger and more varied sample of workers, and consider rater reliability as well. Other variables that could influence dexterity such as age, sex, experience, anthropometric hand dimensions, hand sensitivity and education should also eventually be studied.

There is no doubt that occupational therapists are very concerned about dexterity in their efforts to restore a functional performance in daily living tasks as well as in the work setting. As pointed out by Reed[17] and Kielhofner,[18] in occupational therapy the human being is considered as a whole that cannot be dissociated into parts. In other words, the human being is an association of complex subsystems forming a global system. To pursue this logistic assumption, the vocational or occupational side of a client's life is very tenuously tied to other aspects of his life such as family relations and social interactions. In a rehabilitation program, the occupational therapist is deeply concerned about the interruption of this global system, which could lead to the development of a handicap. If the restoration of dexterity is viewed as a necessary step for the client's return to his or her previous job, then the occupational therapist must be aware of all the consequences.

The aim of this paper has been to draw attention to the scientific validity of dexterity tests used in therapeutic program, and to the importance of correlating the test used with the grip required in performing tasks typical of a vocational activity such as heavy work. With regard to job-related accidents, it is hoped that the method of evaluating dexterity in hand rehabilitation programs will be reexamined, thereby improving the program's effectiveness by encouraging further research into the complex and fascinating subject of human dexterity.

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Proposal for Splinting the Adult Hemiplegic Hand to Promote Function

Anne Mercier Woodson, OTR

SUMMARY. Although there is no general consensus regarding splinting the hemiplegic hand, therapists continue to explore possibilities to facilitate functional use of the involved hand. A proposal for a dorsal splint adaptation, based on neurophysiological principles is described. Its use with two young hemiplegic patients, 10-11 months post onset, is presented. Following consistent use of the splint, both patients showed increased spontaneous use of the hemiplegic hand.

Although there has been much investigation and discussion of splinting the hemiplegic hand over the past hundred years, there is no general agreement among occupational therapists, or others, regarding the rationale for splinting or not splinting the hemiplegic hand.[1] Rationales cited for use of orthotics for the hemiplegic hand include the biomechanical approach, the neurophysiological approach or a combination of these. The biomechanical approach suggests using orthotics as a means of preventing deformity and achieving proper positioning of the hand.[2] The neurophysiological approach looks at using orthoses to promote better balance of muscle tone in the involved extremity.[3,4,5,6]

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Little has been written on the use of orthotics to directly allow or enhance functional movement of the hemiplegic hand. In 1964 Hastings described the use of an adjustable flexor hinge hand splint to achieve a "reach and feed" motion in the upper extremity. The study concluded that "functional bracing of the paretic hand significantly improved hand function."[7] This type of brace, however, is costly to fabricate, difficult for the average hemiplegic to control and is rarely used today in treating the hemiplegic hand.

Perry,[8] in describing bracing as a means of assisting function, recommended the prerequisites of adequate sensation, some finger extension and sufficient cognition to operate a remote control flexor hinge splint used to achieve grasp and release function of the hand. Again, this complicated orthotic arrangement is not thought to be practical for the majority of patients.

Another quite different type of functional orthosis is the thumb positioning splint which is described as a useful device for achieving functional opposition in hemiplegic cerebral palsy patients.[9] This type of splint does not address the problem of lack of sufficient wrist stabilization or finger extension necessary for functional grasp.

Exner and Bonder[10] reported the effects of hand splinting on specific variables of hand function in cerebral palsied children. Three types of splints were used: the orthokinetic cuff, the short opponens thumb splint, and the MacKinnon Splint. They found different responses with different splints and could make no firm conclusions associating improved hand function with a specific splint.

PURPOSE

The purpose of this paper is to describe the development and clinical use of a splint for the adult hemiplegic hand which would allow and promote function.

Through many years of clinical experience with hemiplegic patients, the author has observed that unless some form of hand function is achieved, such as simple weight bearing or gross grasp, the affected upper extremity would not achieve even a minimum level of functional use. In the Functional Test for the

Hemiparetic Upper Extremity, designed specifically to evaluate the hemiparetic person's capacity for function in the involved upper extremity, 15 of 17 of the graded activities involve specific hand movement.[11] Savinelli et al. have further stated that "hemiplegic patients will not use the hand for functional activities other than as a paper weight until they have some selective wrist and finger extension."[12]

TREATMENT

Methods to improve hand movement have not been shown conclusively to improve hand function.[13,14] Yet therapists must always make decisions about continuing to work on upper extremity function in hemiplegic patients based more on each individual patient's physical and psychosocial assets and limitations, rather than on published studies and statistics.

Certain hemoplegic patients, because of particular assets, seem to warrant treatment both in terms of time and methods beyond that considered usual or "cost effective" by a third party payer. These assets can include youth (adults under age 40 or 50), consistent measurable improvements in movement, and motivation to regain use of the involved upper extremity. Ayres has written of the capacity of the brain to reorganize after damage and stated that this plasticity and flexibility diminish with age, suggesting the advantage of youth in responding to sensorimotor remediation.[15] Bach-y-Rita also described plasticity of the nervous system as a factor in recovery of function.[16]

Two CVA patients seen concurrently as outpatients seemed good candidates for development of hand function in the hemiparetic upper extremity. Both were in their twenties and had shown steady improvement in movement of the hemiplegic upper extremity over a ten month period post stroke. Both had gained active shoulder flexion to 90° and reciprocal elbow flexion/extension. Both patients, when their involved arm was relaxed and supported, could demonstrate limited active wrist extension; one had beginning active finger extension. Both, however, demonstrated increased wrist and finger flexor tone in their involved hands during gross upper extremity movement or when attempt-

ing purposeful activities with the involved arm. Neither had any spontaneous use of the involved hand except for occasional weight-bearing stabilization activities. Various neurophysiological treatment techniques designed to improve upper extremity movement and function had been utilized with both patients for approximately ten months. A portion of this treatment focused specifically on increasing hand function. Each patient separately requested a "brace" for his involved hand, hoping this would increase hand function. These requests may have been influenced by the patients' frequent contact with and observations of other patients in this clinic wearing splints for biomechanical reasons, such as for orthopedic problems.

The therapist agreed, in each case, to a trial splint as a means to improve hand function. In determining what type of splint to use, the therapist reviewed the techniques that had been successful for each patient. Both had shown a relaxation of flexor tone in response to a slow sustained stretch to the flexors, facilitation to the extensors and passively applied abduction to the fingers. The latter had been achieved by separating the fingers of the involved hand with the fingers of the uninvolved hand as described by Bobath,[5] and the PNF pattern of finger abduction and extension.[17]

Based on the assessment, a static splint was designed to fit dorsally, to maintain the wrist in neutral and to gently abduct the fingers through the use of separators. The finger separators were adapted from the type of splint commonly used for arthritic patients to prevent MP joint ulnar drift.[18] This splint, (Fig. 1a) cut from one place of thermoplastic material, fits on the dorsal forearm and hand, extending to just proximal of the MP joints with the finger separators curving between the fingers to extend 1/4" to 1/2" onto the volar surface between the metacarpal heads. The splint maintained the wrist in neutral to slight dorsiflexion. Two straps were used, one proximally around the forearm, the other across the palm. The splint maintained the arch of the palm, therefore the palmar strap "bridged" this arch and did not provide pressure into the palmar surface. The splint originally did not include the thumb, (Fig. 1b) but was modified to also include a C-bar to position the thumb in abduction-opposition (Fig. 1d). When applied, the splint did not interfere with forearm prona-

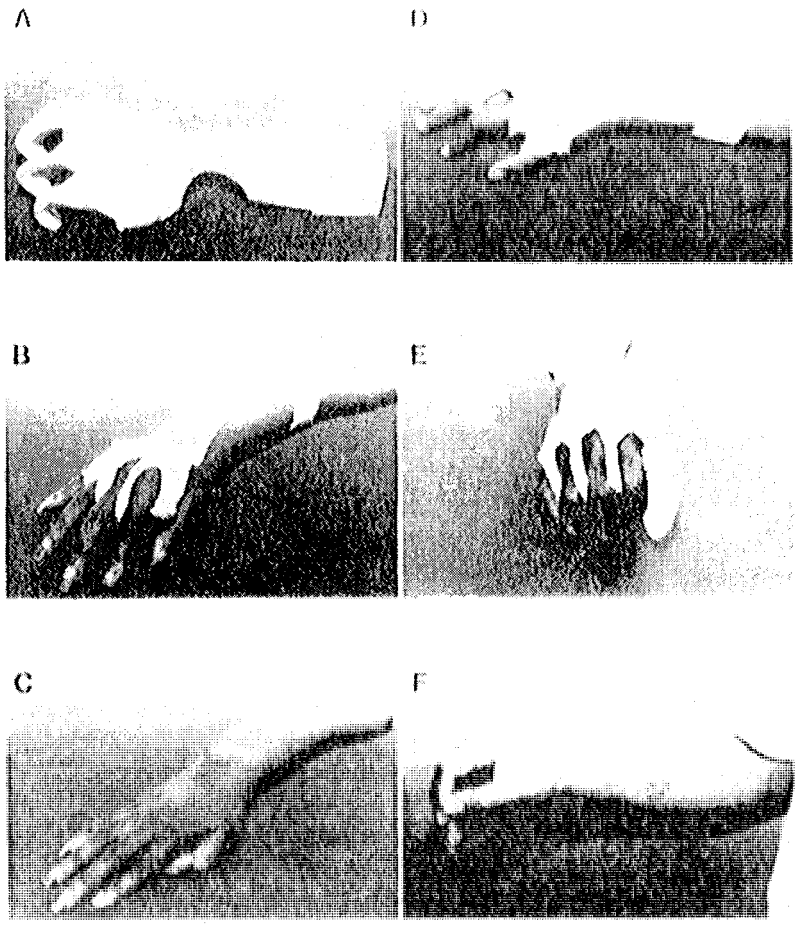

FIGURE 1

A. Dorsal view of splint.
B. Radial view of splint on Patient A.
C. Patient A's involved hand at rest 14 months post-CVA.
D. Splint on Patient B. Note addition of C-Bar thumb positioning.
E. Patient B performing lateral prehension wearing splint.
F. Patient B performing lateral prehension pattern 16 months post CVA.