5-2014

A Randomized Controlled Trial Comparing Contrast Baths to Cryotherapy in Patients with a Wrist Fracture

Elizabeth Ashley Brown
Dominican University of California

Brittany Nicole Phipps
Dominican University of California

https://doi.org/10.33015/dominican.edu/2014.OT.14

A Randomized Controlled Trial Comparing Contrast Baths to Cryotherapy in Patients with a Wrist Fracture

Elizabeth A. Brown

Brittany N. Phipps

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree

Master of Science Occupational Sciences

Dominican University of California

San Rafael, California

May, 2014

This thesis, written under the direction of Dr. Kitsum Li, OTR/L and approved by the Chair of the program, Dr. Ruth Ramsey, OTR/L, has been presented to and accepted by the Faculty of the Occupational Therapy department for partial fulfillment of the requirements for the degree of Master of Science in Occupational Therapy. The content, project, and research methodologies presented in this work represent the work of the candidates alone.

Elizabeth A. Brown, Candidate	12/4/13
Brittany N. Phipps, Candidate	12/4/13
Kitsum Li, OTD, OTR/L, Thesis Advisor	12/4/13
Ruth Ramsey, Ed.D, OTR/L, Chair	12/4/13

Acknowledgments

This thesis project would not have been possible without the guidance and support from our faculty, particularly our professor Kitsum Li. This project was special to her and she took us under her wing while we completed this. Also, we would like to thank Mills Peninsula Health Services and all the participating therapists for allowing us to use their facilities and patients for this research project. We would like to thank Dominican University of California for supplying a grant to fund the use of blind assessors, which was an important aspect of this study. Also, we would like to thank the DUC cohort of 2014. They are a wonderful group who has created a supportive and encouraging environment for us to learn and grow. We will forever consider them our friends. Thanks to Alison Virzi for being a helpful second reader. And a special thanks goes to Mark McAlister for providing direction and extra time on the results of our study.

Elizabeth: I would like to acknowledge my thesis partner, Brittany. I seriously do not know how I would have made it through this entire thesis process without your encouragement and of course all of your silly mannerisms. I would like to thank my mom, dad, stepdad, stepmom, brother, boyfriend and extended family for supporting me throughout my educational achievements. Your love and support is why I am here today and I know that I wouldn't be able to do this without you; I love all of you very much. I would also like to thank all of my loyal friends who have stood by my side and learned how to deal with my busy schedule. I would lastly like to thank Norms Place for catering to all of my shift schedule needs and to all of my coworkers for working extra hard, so I could work on my thesis.

Brittany: I would like to thank my large and supportive family. Dad, Mom, Sherry, Sam, Grandma, Granddad, my many siblings, Amery, and Liam for giving me the resources and confidence to be able to complete this great accomplishment in my life. They have always been a soft place for me to land when I needed support or given me that extra push when life got too comfortable. I would like to also thank the girls of "OTHQ." We started as strangers and I feel so lucky to have been able to live with you girls for this wonderful period in our lives. We have so many great memories together and I hope this is only the beginning of our friendship. Thank you Errol, for coming into my life and showing me how it should have been all along. Thank you for celebrating successes with me and being my person when I needed it. Liz, thanks for being not only a roommate but also an amazing thesis partner. You and I have shared many laughs, tears, and stress through this process and I'm so happy we went through this experience together!

Table of Contents

List of Figures

List of Tables

Abstract

Cryotherapy and contrast baths are common modalities used to treat edema. Despite the fact that many hand therapists report using contrast baths with their patients, there is still little evidence on the effectiveness of them. A Randomized Controlled Trial-Repeated Measures Design was employed to compare the effectiveness of contrast baths to cryotherapy. Participants were recruited after a period of post-fracture immobilization. Blind assessors attained measurements in range of motion, pain, and edema in the 1st, 2nd, and 4th weeks. Participants were randomly assigned to either use cryotherapy or contrast baths at home during the 4-week study period. The participants in this study were asked to keep a home program log to record the number of times that they were able to complete their assigned modality. Also, at the final measurement appointment, the participants were asked to complete a survey indicating their satisfaction with their assigned home program. The results from the ANOVA indicated that there was statistical significance for all the measurements ($p < .05$) except for palm circumferential and volumeter. The results from the home program logs indicated that the adherence for contrast baths had a mean of 2.03 ($SD = 0.76$) times per day and the cryotherapy group had a mean of 1.75 ($SD = 0.98$) times per day. The researchers also noted a trend that the contrast baths group may have a larger effect in the first two weeks of treatment, while the cryotherapy group may have more gradual improvements throughout the four weeks. The results of this study found that adherence for contrast baths and cryotherapy had similar home program adherence and that the participants had similar experiences.

Introduction

In the United States wrist fractures account for 17% of fractures treated in emergency rooms and 16% of all orthopedic surgeries performed (Voda, 2011). Distal wrist fractures are the most common type of wrist fracture and are estimated to occur at a rate of 150,000 to 200,000 per year (Walsh, 2012). A wrist fracture is a fracture to the distal radius, with or without an associated ulnar fracture (Bamford & Walker, 2010). During a fall, people are most likely to place their hands in front of them in order to protect their head, which usually results in injury to the wrist (Altizer, 2008). Protective extension has a higher prevalence in the younger population. As we age, protective extension decreases and there are more incidents of hip fracture and head injury with falls. Other common risk factors for wrist fractures are osteoporosis, sport related injuries and accidents in general (Voda, 2011).

The most common side effect to a wrist fracture is edema. Edema is the normal response of the body as part of the healing process after an injury. Edema becomes problematic when it lasts for longer than the normal amount of time and it can be painful. Edema limits an individual's range of motion (ROM), which affects their overall hand function (Klein, 2007). There are many modalities employed to decrease edema after a fracture. The most common modality is cryotherapy, which is also known as icing. Contrast baths are another known modality but even though 70% of hand therapists report using them, there is still little evidence that supports their use (Breger-Stanton, Lazaro, & McDermid, 2009).

Contrast baths and cryotherapy are primarily used in the clinic setting but they can also be used at home. When performed at home, the individual is responsible for

implementing his or her own treatment at the recommended frequency by their therapist. An individual is more likely to comply with using the modality if it is easier or more convenient to use.

The purpose of this study was to compare the effectiveness of cryotherapy and contrast baths in decreasing edema to improve hand function after a wrist fracture. The research questions were: 1) Are contrast baths as effective as cryotherapy in reducing edema to improve hand function after a distal wrist fracture? 2) Do contrast baths when compared to cryotherapy have a similar home program adherence? This study adds to the literature on contrast baths as well as provides occupational therapists with evidence that supports the use of contrast baths as an effective modality in hand therapy.

Literature Review

In this section, the authors reviewed the healing process and the modalities used to decrease edema in order to improve hand function after a distal wrist fracture.

Wrist Fracture

Anatomy and movements of the wrist. The anatomy of the wrist consists of eight carpal bones in the hand and the distal radius and ulna, which are located in the forearm. The joints include the distal radioulnar and the radiocarpal joints. The most critical function in the wrist is to position the hand for functional use in the distal upper extremity. The wrist is able to move in many different planes, including: flexion and extension, radial and ulnar deviations, and pronation and supination. Flexion describes the movement of the wrist toward the forearm and extension describes the movement of raising the back of the hand. Radial deviation is movement of the hand towards the thumb and ulnar deviation is movement of the hand towards the little finger. Pronation

and supination occur when the wrist rotates up and down, as in turning the palm up and down while turning a doorknob. An individual who is able to produce movements in all of these planes will have optimal hand function and be more likely to engage in meaningful occupations through the use of their hands.

Overview of wrist fractures. Wrist fracture is a common traumatic condition and represents the majority of upper limb fractures (Bamford & Walker, 2010). An injury to the wrist can impact occupational performance because the wrist plays an important role in many functional activities (Brodeur-Lyons & Oaks, 2009). The radius is the most commonly involved bone in a wrist fracture even though wrist fractures can also occur in the ulna and the carpal bones. Many fractures in this part of the wrist have formal names that describe the location and direction of the fracture. These include: Colles, Smith, Barton (volar and dorsal type), Chauffuer, Galeazzi and Monteggia (Walsh, 2012).

How wrist fractures occur. Fractures occur when excessive force is applied to the bones. This is often the case in falls because individuals use their protective reflex and extend their hand and arm in front of them to prevent injury to their head. The impact of the hand on the ground during a fall often forces the wrist into hyperextension, resulting in a blunt force on the wrist upon contact with the ground (Alitzer, 2008; Walsh, 2012). The protective reflex of the arm decreases with age. While distal wrist fractures are more common in younger adults, the elderly are more likely to sustain a hip fracture or a head injury during a fall as a result of decreased protective arm extension (Leahy, 2011; Sran, Stotz, Normandin, & Robinovitch, 2010).

Risk factors for wrist fractures. Risk factors that contribute to wrist fractures include: osteoporosis, sport related injuries, and accidents.

Osteoporosis. Individuals with osteoporosis are at the greatest risk for wrist fractures because of their lower bone density. In a case-control study performed by Oyen et al. (2011), the researchers found that those with distal wrist fractures were more likely to have osteoporosis than individuals of similar age without osteoporosis. Also, postmenopausal women who have lowered bone mineral density, but do not have osteoporosis, experience more distal radius fractures than premenopausal women (Leahy, 2011).

Sport related injuries. Children and young adults increased participation in sports has led to an increase in the occurrence of wrist fractures (Voda, 2011). In a study by Taylor and Attia (2000), they found that wrist fractures were the most common injury for sport related injuries in children. A population based study surveying over 100,000 people over a 12-year period revealed that soccer and gymnastics had the highest incidence of wrist fractures in children ages 10-19 (Putter et al., 2011).

Accidents. Both low and high energy injuries can lead to wrist fractures. Motor vehicle accidents are considered high energy injuries and are more likely to cause wrist fractures in young adults. Falls are considered low energy injuries and are the leading cause of unintentional injury in older adults (Sran, Stotz, Normandin, Robinovitch, 2010; Walsh, 2012).

Overview of Edema

Swelling is common after surgeries or injuries and is the normal response of the body to transport cells and nutrients that are important for healing to the injured area (Klein, 2007). Normal reduction of swelling occurs about two weeks after an injury and can take a number of months to completely subside. Edema that is excessive and does not

begin to gradually decrease within two weeks can become problematic because it can gel, known as the fibrotic process (Klein, 2007).

The process of edema. There are three primary phases in the edema process: inflammatory phase, fibroplasia phase, and maturation phase. The inflammatory phase, which lasts three to five days post injury, occurs when there is excess fluid due to the initial vasoconstriction and then vasodilation. Managing this fluid should be relatively easy as long as common modalities are used to minimize pooling of blood in the injured areas (Villeco, 2012). The fibroplasia phase lasts two to six weeks and includes increased capillary growth, increased fibroblasts, and is where new collagen synthesis occurs. If edema is still present at this point it becomes more viscous due to the increased protein content. The lymphatic system can become overwhelmed from the persistence of the edema (Villeco, 2012). If edema still persists in the maturation phase (six months to two years) it often leads to fibrosis, which occurs when the fluid becomes hard, thick, and firm. Due to the increase in proteins in the interstitial fluid, the body draws more fluid to the area to normalize the concentration. This increase in fluid causes the lymphatic fluid to clog, which in turn reduces the normal pressure of the system and makes it inefficient to remove the fluid sufficiently. This creates excess edema around the injured cells which compromises nutrition in the area. Treatment of edema in the maturation phase may require the edema to be softened before it can be mobilized (Villeco, 2012).

How it affects function. There are several different mechanisms for edema to interfere with hand function. Edema can interfere with function when swelling compromises the diffusion of waste and nutrients between the blood capillaries and the cells. This puts the patient at risk for delayed healing, infection, skin breakdown, and cell

damage (Villeco, 2012). Also, gelling of the edema can decrease joint space and increase stiffness, which interferes with joints and tendons gliding motion. When gelling occurs at the wrist joint, the decrease in wrist motion can in turn interrupt normal hand function (Klein, 2007). Early management of edema is important in order to prevent movement impairment and the development of fibrotic tissue (Haren & Wiberg, 2006). Edema also leads to an increased amount of fluid within the interstitial spaces where the injury occurred. This increase in interstitial fluid places more pressure on the pain receptors in the skin, which causes an increase in pain (Priganc & Ito, 2008).

Interventions and Modalities Used for Edema

There are many interventions used to manage edema after an injury. In addition to cryotherapy and contrast baths, some of the most common treatments to reduce edema after a wrist fracture are compression garments, retrograde massage, Kinesiotape, active motion, and positioning.

Compression garments use counter pressure of working muscles and external compression to improve the efficiency of circulation (Zuther, 2009). Isotoner gloves, intermittent pneumatic compression devices, and self-adherent wraps, such as Coban are examples of compression bandages (Villeco, 2012). In a randomized controlled trial that studied the efficacy of exercise and compression garments in 19 patients with breast cancer, the researchers found that compression garments and exercise were an effective way to treat lymphedema in the upper extremity (Irdesel & Çeliktas, 2007). Retrograde massage is referred to as gentle massage on the affected limb to slowly push the fluid from distal to proximal. This type of intervention assists in blood and lymph flow circulation (Lewis, 2003). In a quasi-experimental study, Priganc and Ito (2008) found

that manual edema mobilization in persons with orthopedic injuries, effectively decreased edema in four of the five subjects, which supports the efficacy of this modality. Kinesiotape is an elastic adhesive tape that lifts the fascia and removes edema by directing the swelling to a lesser congested area. Kinesiotape is designed to be the same thickness as the epidermis, which helps to increase circulation of the blood and lymph fluids (Villeco, 2012). In a randomized controlled trial by Bialoszewski, Wozniak and Zarek (2009) conducted a study of 24 patients with postoperative edema of the thigh. The researchers found that Kinesiotape had a significantly faster reduction in edema when compared to lymphatic massage in patients with lower extremity edema. Active motion is defined by any movement done by the individual such as exercise. An example of active motion is tendon gliding, which can be done any time the individual is able to tolerate any ROM in his or her hands and fingers (Wehbe, 1987). Active motion stimulates lymph propulsion to the lymphatic vessels that do not contain smooth muscle. Correct positioning of the hand for edema includes placing the hand above the level of the heart. Examples of this positioning would be propping the hand on pillows while sitting and resting the hand on an elevated surface so that the elbow is in extension (Kasch & Walsh, 2012).

Cryotherapy. Cryotherapy, the application of cold, is one of the oldest and easiest modalities used to manage edema after an acute injury (Bleakley, McDonough & MacAuley, 2004; Kanlayanaphotporn & Janwantanakul, 2005). Cryotherapy uses cold temperatures to treat edema, pain, and inflammation. The cold facilitates vasoconstriction in the tissues, which helps to decrease the amount of blood flow to the injured area

(Brienes, 2012). Some of the practical advantages of cryotherapy are that the ice or ice pack are readily available in most homes and are inexpensive (Dykstra et al., 2009).

Physiological effects of cryotherapy. Researchers have studied the effects of many methods of cold application on the human body. Cold application reduces nerve conduction velocity, decreases local blood flow, and decreases the metabolic rate. These in turn reduce pain, edema, inflammatory reactions, and secondary hypoxic damage. For cold temperatures to have an effect on metabolic rate, the skin surface and tissue temperatures should be lowered to 10 °C (50 °F). To reduce nerve conduction velocity, a temperature of at least 12.5 °C (54.5 °F) is required (Chesterton, Foster & Ross, 2002, Kanlayanaphotporn & Janwantanakul, 2005).

Types of cryotherapy. There are various procedures used to apply cold to an injured area. The wide range of types of cryotherapy that produce different effects and offer varying advantages and disadvantages, in terms of ease of use, cost, and personal preference (Chesterton et al., 2002). Some of the different types of cryotherapy are ice massage, cooling machines, and commercial gel packs. Ice massage is most often used when the area to be treated is small and specific. The individual uses a large piece of ice, which is frozen in a paper cup and massages the area in a circular motion for approximately five minutes or until the area is numb. Cooling machines circulate cold water through tubes in a pack that is wrapped around the injured area. Cooling machines can maintain cold temperatures for a long time but are fairly expensive (Brienes, 2012). Many health supply companies make commercial gel packs. These packages contain a gel substance that is frozen and is used to ice an injured area. The use of a protective layer between the gel and the skin is recommended to prevent any damage to the skin.

Furthermore, individuals may also use commonly found items at home, such as a frozen bag of vegetables or a frozen mixture of alcohol and water in a Ziploc bag as a method of cryotherapy. Even though there is established agreement on the benefits of cryotherapy, there lacks strong evidence to justify the use of one application of cold over another (Kanlayanaphotporn & Janwantakul, 2005).

Comparisons of different types of ice. Researchers have studied the different temperatures that are commonly used in cold application. In a study completed by Dykstra et al. (2009), researchers revealed that wetted ice is more effective than crushed or cubed ice in reducing surface and intramuscular temperature during treatment. In addition, wetted ice was also found to be able to maintain the therapeutic temperature the longest. A wetted ice pack (an ice pack that has begun to melt) is more beneficial in the clinical setting than a freshly made ice pack for treating injuries and reducing analgesia (Dykstra et al., 2009). Also, cold modalities that undergo a phase change (from solid to liquid) are generally more effective than those that do not (Dykstra et al., 2009). In the study by Chesterton et al. (2002), the researchers demonstrated that a bag of frozen vegetables was able to reduce the skin surface temperature to less than 10 °C (50 °F) while the frozen gel pack was not able to achieve this. Kanlayanaphotporn and Janwantanakul (2005) conducted a study to compare the temperature changes between an ice pack, a frozen mixture of alcohol and water, frozen vegetables and a gel pack. They found that an ice pack and a frozen mixture of alcohol and water were able to decrease the skin surface temperature to levels that would provide the client with therapeutic effects. On the contrary frozen vegetables and the gel pack were not able to cool the skin enough to provide these same effects (Kanlayanaphotporn & Janwantanakul, 2005). The

differences in these findings may be due to the differences in the size and weight of the cryotherapy packs used as well as the time applied.

Contrast Baths. Contrast baths are a thermal treatment modality that have been used in hand therapy clinics for over 70 years. Contrast baths combine alternating the hand in warm and cool water for a specified temperature, time, and duration (Breger-Stanton, Lehman, Graziano & Ryan, 2003; Breger-Stanton et al., 2009). Contrast baths are used to alleviate pain, stiffness, and edema. Alternating between the warm and cool water temperatures allow for an increase in blood flow and decrease of joint stiffness. This is done by externally inducing vasoconstriction and vasodilation that is normally performed by normal contracting muscles (Breger-Stanton, et al., 2003). Over 70% of hand therapists use contrast baths in their practice (Breger-Stanton et al., 2003). Hand therapists who do not use contrast baths have reported that there is a lack of published evidence to support their use (Janssen et al., 2009).

Physiological effects of contrast baths. Alternating between warm and cool water helps to increase vasodilation and vasoconstriction in the body. This imitates the way the body naturally increases blood flow and removes metabolites to help with recovery. Therefore, contrast baths have been used to reduce edema by stimulating the area-specific blood flow, relieving stiffness and pain, increasing ROM, and reducing the onset of muscle soreness (Wilcock, Cronin, & Hing, 2006).

Protocols: Temperature, timing, and duration. Though many hand therapists use contrast baths in their clinics, there is no specific protocol for the time, duration, and temperatures on how to apply this modality. In a systematic review on contrast baths

completed by Breger-Stanton et al. (2009), they reviewed multiple studies and discovered that therapists varied on how they administered contrast baths.

Artzberger (2007) stated that blood flows best when temperatures are between 72 °F and 106 °F. As a therapist using contrast baths the temperature of the hot water should not exceed 98 °F for safety reasons (Artzberger, 2007). Other researchers have indicated what they believed to be the best temperatures for contrast baths and these have ranged from 47 to 60 °F and 106 to 113 °F (Breger-Stanton et al., 2009). The amount of time the affected hand is immersed in either the warm or cool water varies as well. Breger-Stanton et al. (2003) indicated that some researchers advocated the immersion of the hand in warm water for 10 minutes and then the hand in cool water for one minute. Other researchers believed that the ratio should be a shorter immersion time such as three minutes in warm water to one minute in cool water (Shih, Lee, Huang, & Wu, 2011). The total duration of contrast baths varies from 15 to 30 minutes, twice a day (Cochrane, 2004).

In a randomized controlled trial, Janssen, Schwartz, and Velleman (2009) evaluated the benefits of contrast baths on 114 participants with Carpal Tunnel Syndrome and found that contrast baths had no significant effect on decreasing hand volume in the participants. They used hand volumetry to measure total hand volume and therefore edema. The measurements were taken on two separate groups of participants, 58 participants before carpal release surgery versus 56 participants after the surgery. The researchers standardized the contrast baths to have one minute of warm water immersion to one minute of cool water immersion. They also standardized the water temperature for cool water to be at 70 °F and the warm water to be at 105 °F. The participants were

randomized into three treatment groups: contrast baths with exercise, contrast baths without exercise, and exercise only. The researchers obtained data regarding hand volume before and after treatment.

Adherence to Home Program

Occupational therapists prescribe home programs to supplement the treatment being offered in the clinic. A home program can include exercises, stretches, and modalities such as ice or contrast baths that the client self-administers at home. Adherence to a home program is an important predictor of a better outcome in therapy (Lyngoln, Taylor, Pizzari, & Baskus, 2005). Bamford and Walker (2010) using a qualitative approach interviewed six patients at an outpatient occupational therapy department, who all recently sustained a wrist fracture. The researchers found through the semi-structured interviews that the participants realized they had a responsibility during their rehabilitation process. The participants advocated that occupational therapy was a key element in their motivation. Hence, Bamford and Walker (2010) concluded that participants who received instruction from an occupational therapist were more likely to be compliant with their home program.

In a prospective randomized controlled trial conducted by Souer, Buijze, and Ring (2011), 94 patients with an unstable distal radius wrist fracture treated with an open reduction and volar locking plate fixations participated in this study. The researchers compared exercises performed under the supervision of an occupational therapist with surgeon-directed independent exercises. The study revealed that an independent exercise program assigned from a surgeon without occupational therapy was found to be more effective in improving ROM and strength when compared with patients who received

occupational therapy alone. This is because patients may benefit from a more active and self-reliant role as opposed to a more passive one (Souer, Buijze, & Ring, 2011). This demonstrates the importance of adhering to a home exercise program while recovering from a distal wrist fracture.

Review of Assessment Tools- Reliability and Validity

Reliability and validity are two different measures that clinicians use to ensure that data is accurate and meaningful. Reliability is the extent to which a measurement is consistent and free from error. Validity is the degree that the assessment measures what it is intending to be measured (Portney & Watkins, 2009).

Goniometer. Goniometer is the gold standard in the measurement of ROMs in a joint. Many factors such as the environment, goniometer placement, and client related factors can affect the reliability of ROM testing. The inter-rater reliability for finger joint goniometer ranged from .832 to .973, depending on the joint and motion (Engstrand, Krevers, & Kvist, 2012). Ellis and Bruton (2002) found that inter-rater reliability for goniometer measurements to fall within seven to nine degrees, 95% of the time. Combined finger flexion was found to be reliable when measured by different therapists, but individual joint measurements were found to be more reliable when performed by one therapist (Ellis & Bruton, 2002). According to the American Society of Hand Therapists (ASHT), there is a five-degree margin of error with goniometer measurements on any specific joint at a given time (Apfel, Johnson, & Abrams, 2002).

Dynamometer/ Pinch Gauge. The dynamometer is a standard hand strength measuring instrument and is currently regarded as the gold standard for hand strength measurements (Shechtman, Gestewitz, & Kimble, 2005). The dynamometer and

pinch meter measure grip strength, lateral pinch, two-point, and three-point finger strengths. The inter-rater reliability for grip strength, lateral pinch, two-point pinch, and three-point pinch are .997, .978, .976 and .973 respectively. The margin of error is believed to be three percent for the dynamometer (Lindstron-Hazel, Kratt, & Bix, 2009).

Volumeter. The volumeter uses water displacement to measure the volume of the hand. The inter-rater reliability for the volumeter is .99. A study performed by Dodds, Nielsen, Shirley, Stefaniek, & Moyers (2004) showed that the margin of error was three milliliters in a commercial volumeter used in the prescribed manner. However, previous findings from Wehbe (1987) found that the margin of error in displacement volumeter measurements could be as high as 10 milliliters.

Circumferential Measurements. Circumferential measurement is the use of measuring tape to measure the distance (in inches) around part of a limb or anatomic area. It is common to measure both circumferences of the wrist and the palm. The margin of error is calculated through comparisons of controlled measurements with different assessors. The margin of error was found to be a .25 of an inch. The inter-rater reliability at the wrist is .97 to .98 (Taylor, Jaysinghe, Koelmeyer, Ung, & Boyages, 2006) and there is no reported inter-rater reliability for the palm circumference.

Visual Analog Pain Scale. The Visual Analog Scale (VAS) is a simple and commonly used assessment tool that measures subjective pain intensity. Participants are instructed to indicate the intensity of their pain on a scale of one to 10, where one indicates no pain at all and 10 indicates severe pain. The validity of this pain measurement cannot be determined directly. In a study on the intra-subject variability and

correlation of the VAS, it was found that the VAS seems to be a valid measure of pain (DeLoach, Higgins, Caplan, & Stiff, 1998).

Statement of Purpose

The purpose of this study was to investigate the effectiveness of contrast baths in reducing edema and to improve hand function for patients with distal wrist fractures participating in hand therapy. Another purpose of this study was to investigate if contrast baths or cryotherapy are an easy-to-use program that may lead to a greater adherence to home programs. The null hypotheses for the study were 1) cryotherapy is more effective than contrast baths in reducing edema with distal wrist fractures, 2) cryotherapy is more effective than contrast baths in improving hand function for individuals with a distal wrist fracture and 3) cryotherapy has better home program adherence than contrast baths. Hence, our alternative hypotheses were 1) contrast baths are as effective as cryotherapy in reducing edema with distal wrist fractures, 2) contrast baths are as effective as cryotherapy in improving hand function for individuals with distal wrist fractures and 3) contrast baths compared to cryotherapy will have a similar home program adherence.

Theoretical Framework

Biomechanical

The biomechanical frame of reference applies the principles of kinetics (movement against force and resistance) and kinematics (the science of motion without consideration of mass and force) to the movement of the human body. The biomechanical framework is concerned with motion during an occupation and is used with individuals who experience limitations in movement and inadequate muscle strength during occupations (Helsel & Graveline, 2001). After a wrist fracture individuals experience

limited ROM due to edema, which in turn limits hand function. Occupational therapists using a biomechanical perspective view limitations in client factors and analyze the movements required to engage in meaningful occupations (Schultz-Krohn & Pendleton, 2012). According to the Occupational Therapy Practice Framework, client factors are observable, concrete, goal directed actions that individuals use to engage in daily life activities (AOTA, 2008). When an individual sustains a wrist fracture, their client factors are greatly impacted.

The biomechanical frame of reference was chosen to guide the research because it typically uses physical improvements in strength and ROM to demonstrate effectiveness of therapy. A biomechanical disability, such as a wrist fracture, is often related to the inability to perform activities of daily living and instrumental activities of daily living due to limitations in (ROM) and strength. An occupational therapist using a biomechanical approach will create goals and objectives that address basic client factors in order to improve occupational performance (Cole & Tufano, 2008a; Schultz-Krohn & Pendleton, 2012).

After individuals sustain a wrist fracture they begin to experience limitations in ROM and strength. ROM involves the angles and directions of movement and is assessed with a goniometer reading of the degrees of movement at the axis of each joint in the wrist and hand. Occupational therapists are concerned with ROM when an injury or illness causes an extended period of immobility, such as the initial immobilization period typical to a wrist fracture.

Strength refers to both the stability and motion that is produced by muscle tension. Strength is impaired during a wrist fracture due to the limited ROM that the individual

experiences from the edema. If strength is compromised after an injury, the individual will experience difficulties in normal daily activities that require force such as turning on the ignition of their car.

The use of physical agent modalities (PAM) to reduce pain and edema is included in the biomechanical approach. Occupational therapists using this frame of reference will work on reducing edema in an individual's wrist and hand in order to improve their hand function (Cole & Tufano, 2008a; McMillan, 2002). Contrast baths as a PAM incorporate superficial hot and cold agents to reduce edema. The warm water helps to reduce pain, increase blood supply and increase collagen elasticity, which reduces joint stiffness (Cole & Tufano, 2008a). The cold water and ice lower body temperature, which reduces internal swelling (Cole & Tufano, 2008a). ROM and strength may improve as a result of edema reduction. Improvement in ROM and strength through the use of contrast baths or cryotherapy may in turn help improve hand function for better engagement in occupations.

Person Environment Occupation (PEO)

When an individual experiences an injury, his or her ability to perform occupations independently can be altered. The PEO model is the study of occupational performance from an ecological point of view. The three components of PEO include: the person, the environment, and the occupation (Dunbar, 2007). The individual's skills and abilities are the person component of the PEO. The occupation consists of activities that are meaningful to an individual and the environment is the setting in which the occupations take place. The interaction of the person, occupation, and environment create occupational performance. The closer the fit between these three components the better

the individual's occupational performance will be (Cole & Tufano, 2008b). Thus, the PEO model can be used to guide a therapist in educating the individual on how to perform activities independently by providing a better fit to the person, the environment and the occupation.

The person aspect of the PEO includes the individual with his or her distal wrist fracture and the deficits that arise from the wrist fracture, such as edema. The occupation of the individual includes the activities that he or she participates in, which in this case would include his or her prescribed home program of cryotherapy or contrast baths. The environment includes the individual's home or work environment where the home program will be carried out. The environment exerts an important and continual influence on an individual's behavior (Dunbar, 2007). For instance, if an individual's work environment is outdoors and he or she has difficulties doing cryotherapy or contrast baths then this would affect the fit of the PEO. Also, if an individual did not have access to two tubs or sinks at home, this may hinder his or her ability to perform contrast baths in the home setting. By having a home exercise program that is easier to complete within the environment, the individual will have a better fit between his or her occupation, and person. The better the fit of the environment with the individual, the more likely the individual will adhere to the home exercise program.

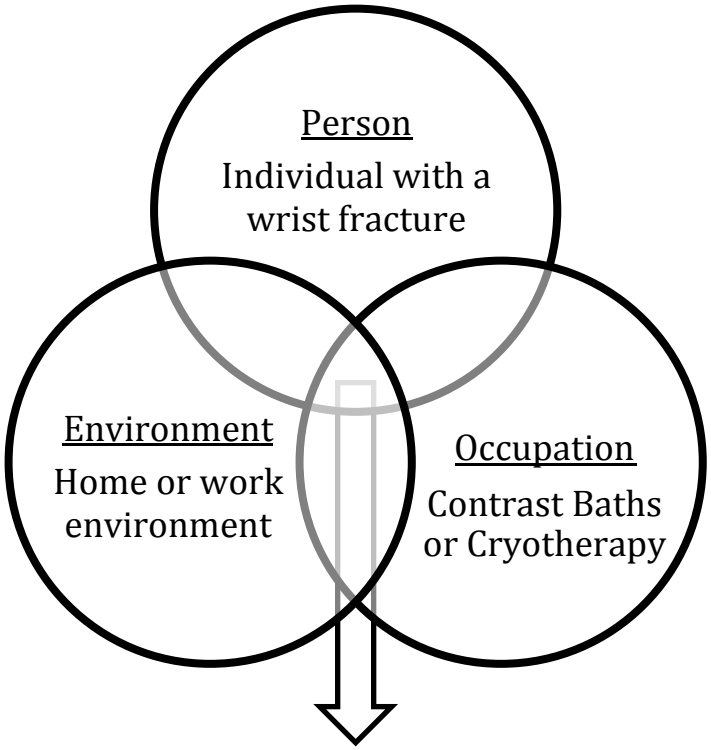


Figure 1 *The Person Environment Occupation (PEO) Model*

Definitions and Variables

- Edema: An abnormal infiltration and excess accumulation of serous fluid in connective tissue or in a serous cavity (Webster Online Dictionary).
- Cryotherapy: The therapeutic term for cold, also known as icing (Webster Online Dictionary).
- Contrast Bath: Known as warm/cool immersion therapy. A form of treatment where a limb is immersed in cool water and then immediately immersed in warm water. This procedure is replicated several times (Webster Online Dictionary).

- Goniometer: An instrument for measuring angles and movement at a joint (Webster Online Dictionary).
- Volumeter: An instrument used to measure volumes by displacement of water (Webster Online Dictionary).
- Circumferential Measurements: The use of measuring tape to measure the distance around a part (in inches) of a limb or anatomic area.
- Visual Analog Pain Scale (VAS): Is a subjective measurement instrument that tries to measure a characteristic or attitude, and in this case pain level, that is believed to range across a continuum of values and cannot be directly measured (Bijur, Silver, & Gallagher, 2001).
- Semmes-Weinstein Monofilament: A sensory tool that provides a non-invasive of cutaneous sensation levels throughout the body with results that are subjective and repeatable (Operational Manual).

Methodology

Design

This study employed a randomized controlled trial (RCT) to compare the effectiveness of contrast baths and cryotherapy in reducing edema and improving hand function after a distal wrist fracture. Components of a RCT include a control group, randomization and manipulation of a variable (Portney & Watkins, 2009). The control group in this study was the cryotherapy group and the experimental group was the group that used contrast baths. The participants were randomized through the use of a Microsoft Excel Randomization Table (Appendix A). The last two digits of the Medical Record Number (MRN) were used to match with the randomization table and the group

assignment. Blinded assessors were used for pre and post-test measurements to prevent experimental bias. Blinded assessors took active range of motion (AROM), edema, strength, pain, and sensory measurements of the participants at the initial visit, two, and then four weeks. The blinded assessors were trained by the lead researcher on the protocols to use while measuring the patients. In between the measurements, the participants received standard hand therapy in the clinic and were expected to use their assigned modality, ice or contrast baths, both in the clinic and at home. The pre and post-test measurements were used to determine the effectiveness of the two modalities. The dependent variables in this study were edema, pain, hand strengths, ROMs in forearm, wrist, and fingers. The independent variables in this study were the two modalities, contrast baths and cryotherapy.

Mills-Peninsula Health Services

Mills Peninsula Health Services has two campuses. Peninsula Medical Center is located at 1501 Trousdale Drive Burlingame, California. Mills Health Center is located at 100 South San Mateo Drive San Mateo, California. Mills Peninsula Health Services provides a wide range of surgical, emergency, and diagnostic services, in both inpatient and outpatient settings (Mills-Peninsula Health Services, 2012).

Mills-Peninsula hand therapy clinics employ eight occupational therapists that are licensed in California with advanced practice licenses in hand therapy, two of which are also certified nationally as Certified Hand Therapists. The therapists' experience ranges from eight to 30 years in hand therapy. The hand therapy clinics treat many diagnoses relating to the upper extremity including: repetitive injuries, Carpal Tunnel Syndrome,

De Quervain's Syndrome, surgical tendon repairs, and fractures. The hand therapy takes place in an outpatient setting in either Mills Health Center or Peninsula Medical Center.

Subjects

The target population for this study was English-speaking adults, 18 and older with a recent distal wrist fracture and four to eight weeks post fracture. The participants in this study were recruited from referrals made to the hand therapy clinics at Peninsula Medical Center and Mills Health Center after the period of post-fracture immobilization. Referrals for the study came from orthopedic surgeons in San Mateo County, California.

An announcement of the study was made to the hospital and local physicians (Appendix B). Referrals were made from the physicians after the participants sustained a distal wrist fracture and were ready to begin mobilization. Inclusion criteria for this study included a recent distal wrist fracture, with or without surgical intervention. The participants were required to be able to provide their own consent to participate. Participants were excluded from the study if they had any of the following conditions: Complex Regional Pain Syndrome, tear of the Triangular Fibrocartilage Complex, open wound present at the site of injury and any nerve injury. Additionally, participants were excluded if they exhibited any cognitive deficits that resulted in them not being able to understand the requirements of the home program. Participants in the study were not excluded if they had undergone surgery for treatment of their distal wrist fracture.

When a referral was received by the clinic, the researchers screened the patient over the phone to determine fulfillment of inclusion criteria using a script (Appendix C). If a patient met the inclusion criteria, he or she was asked to come in 30 minutes prior to his or her first scheduled therapy appointment to be evaluated.

Ethical and Legal Considerations

The researchers obtained approval from the Institutional Review Boards of Dominican University of California (IRBPHS #9089) and Mills-Peninsula Health Services on April 12 and April 26, 2012 respectively. The researchers also abided by the Occupational Therapy Code of Ethics and Ethic Standards (statements of principles used to maintain standards within the profession), in order to uphold the ethical responsibility to the participants in the study (AOTA, 2010).

The principle of beneficence refers to all forms of action intended to benefit others (AOTA, 2010). Under this principle, the researchers promoted healing in their participants by offering them treatment to reduce their edema, thereby improving their hand function. Also, under this principle the researchers re-assessed each participant to ensure that the provided modality was effective for the individual. The researchers ensured that all ethical guidelines were being followed under the beneficence principle.

Non-maleficence protects the research participants from harm. Under this principle it was the researchers' duty to report potential risks to the participants (AOTA, 2010). The researchers verbally discussed and provided a handout with the potential risks and ways to eliminate potential harm to the participants. Also, the participants were allowed to withdraw from the study at anytime with no repercussions.

The principles of autonomy and confidentiality express that it is the researchers duty to protect the participant's confidential information as well as to treat the participant according to their desires (AOTA, 2010). The researchers followed these principles by ensuring that all patient data was kept on a password protected flash drive locked in a drawer and a password-protected computer on site. Also, patient names were replaced

with the last four numbers of the patient's MRN, which were included on all patient forms. All Health Insurance Portability and Accountability Act (HIPAA) regulations were followed, and study participants were informed of all benefits and risks, and their participation was voluntary.

Procedural justice concerns following regulations and making fair treatment decisions (AOTA, 2010). The researchers were aware of all institutional regulations and obtained approvals from both Institutional Review Boards before they conducted the research. The researchers obtained approval from Mills Peninsula Health Services before they recruited subjects from their referrals. Each participant was provided with the full disclosure of the study procedure, as listed in the consent form (Appendix D). This was to ensure participants agreeing to participate in the study were fully aware of what the study requirements were, and participation was voluntary.

The principle of veracity is based on providing comprehensive, accurate, and objective information to the patient. This principle also includes fostering the client's understanding of the information (AOTA, 2010). The researchers abided by this principle when educating the patient about this study and the benefits and potential side effects. Also, the blinded assessors abided by this principle when gathering and documenting data from the participant.

Data Collection Procedures

The blinded assessor obtained the consent for the study (Appendix D) from the patients and provided the Patients' Bill of Rights (Appendix E) prior to data collection. The blinded assessor also collected basic demographic information from the participant.

The blind assessor then measured both the client's affected and unaffected hands and documented on the measurement charts (Appendix F).

The blinded assessor measured the participant's AROM for both wrists and hands using a goniometer. AROM of the forearm included pronation and supination. AROM of the wrist included wrist deviations, flexion and extension. AROM in the fingers included total active motions (TAM) in each of the fingers at the metacarpophalangeal (MP), the proximal interphalangeal, and the distal interphalangeal joints. Total active motion of the thumb included movements at the interphalangeal, the MP, and palmar abduction of the thumb. These numbers were added up to give TAM for each of the fingers. The ASHT protocol was followed for the goniometer measurements.

Edema measurements were conducted using standard protocols for palm circumferential, wrist circumferential, and volumeter displacement techniques. Wrist circumference in inches was taken distal to the radial styloid process and palm circumference, in inches, was taken proximal to the MP joints and proximal palmar crease (Kasch & Walsh, 2012). The volumeter measured the total volume of both the hand and forearm through the displacement of water. The hand was introduced into a filled volumeter and the amount of water that was displaced equaled the volume of the hand. The hand was lowered gently until it rested on the dowel rod between the middle and ring fingers (Kasch & Walsh, 2012).

Hand strength was measured using a hydraulic dynamometer. Finger strength was measured using a pinch gauge. To assess a participant's hand strength, his or her grip strength, lateral, two-point and three-point pinches were measured. The standard third span grip of the hydraulic dynamometer was used and the standard positions for lateral,

two-point, and three-point pinches were used. To obtain grip strength the blinded assessor had the patient sit with feet flat on the floor, the shoulder adducted and neutrally rotated, the elbow flexed 90 degrees, forearm in a neutral position, and the wrist between zero to 30 degrees extension and zero to 15 degrees ulnar deviation. The patient grasped the hydraulic dynamometer and gave maximum effort (exerted full force) for one repetition. The two-point pinch was done with thumb tip to index fingertip on the pinch gauge. The lateral pinch was completed by the thumb pulp to the lateral aspect of the index finger on the pinch gauge. The three-point pinch was completed by the thumb tip to the tips of the index and middle fingers on the pinch gauge (Kasch & Walsh, 2012). All patients were cleared by their physicians prior to completing strength testing.

Pain was assessed using the VAS (Appendix G). During the interview, information regarding the quality, frequency, and location of pain, medications, and factors that aggravate and alleviate pain were collected. The VAS is a subjective scale from zero to 10, where the patient graded their pain intensity from zero (without pain) to 10 (excruciating pain). Patients were asked to quantify their pain level at rest and during use.

Test of sensibility was used to screen for nerve injuries, using the Semmes-Weinstein Monofilament testing. Standardization for the Semmes-Weinstein Monofilament testing required the assessor to use a quiet setting and have the patient close his or her eyes. The assessor tested the palmar surface of the index finger and thumb and the dorsum of the 5th finger and the hypothenar eminence (Appendix F). Initially, the assessor started with the 2.83 monofilament and placed it on the patient's hand at a 90-degree angle and left it there for approximately 1.5 seconds. If the patient

did not feel the monofilament then the blinded assessor moved to a larger size until the patient felt the monofilament (Operation Manual). Nerve injuries are an exclusion criteria for this study. This test was used as a screen for any possible nerve injuries that may not have been diagnosed. If the patient was found to have an intact protective sensation (4.31 and below) then they qualified to be in the study (Kasch & Walsh, 2012).

The assessor compiled all the data obtained from the participants into an assessment form (Appendix F) that was kept in the patient's chart until the final measurement was completed. The researchers then transferred and stored the data in a password-protected Microsoft Excel file in a password-protected computer on site and on a flash drive. The flash drive was used for initial data entry and all data were transferred to a password-protected desktop computer on site. The flash drive was locked in a drawer on site between uses. The hospital was responsible for storing the charts and all employees abided by the HIPAA. The measurements were shared with the treating therapist and integrated as part of the participant's medical record. In order to protect the participant's confidentiality only the last four digits of their MRN were included on all data forms.

On the second and fourth weeks of therapy, the participant returned 15 minutes before his or her appointment to be re-measured by a blinded assessor. During these follow up visits, the participant was only measured on their affected side. All measurements were re-measured using the same established protocol.

The participants kept a frequency log to track adherence to home program (Appendix J). The participants received this log at their first therapy session when they were instructed on their home program. They were asked to return the log at their fourth

week final re-measurement. During the final re-measurement the participants of the study were also asked to complete a short survey (Appendix K) regarding the ease and satisfaction with their assigned home program.

Intervention

The treating therapist used the randomization table (Appendix A) to determine which home program group the participant would take part in. The therapist provided the patient with written instructions and demonstration of the assigned program in the clinic (Appendix H & I). The therapist also provided the patient with an intervention according to standard hand therapy practice.

Data Analysis

The purpose of this study was to determine the effectiveness of contrast baths as compared with cryotherapy in reducing edema and improving hand function after a wrist fracture using a repeated measures design. The data collected were ordinal data. Assessors input data into Microsoft Excel and transferred to SPSS software for statistical analysis. T-tests were used to test for homogeneity between groups. Factorial ANOVA was used to determine within group and between group differences. Lastly, Pearson Product- moment coefficient was used to investigate correlation between extraneous and dependent variables of pain and volume of hands. The post-study survey and home program adherence log were examined to investigate the participant's experience with their ability to adhere to their assigned modality. Lastly, demographic and distribution information were also reviewed.

Results

As shown on Figure 2, 49 patients were referred to Mills Peninsula Hand Therapy clinics due to wrist fractures. Of those 49 patients, 16 refused to participate in the study and nine did not meet the inclusion criteria of the study. Of the remaining 24 patients, two were disqualified and two refused to participate in the study after the initial assessment. A total of 20 participants were randomly assigned to contrast baths or cryotherapy; eleven participants were assigned to the contrast baths group and nine into the cryotherapy group.

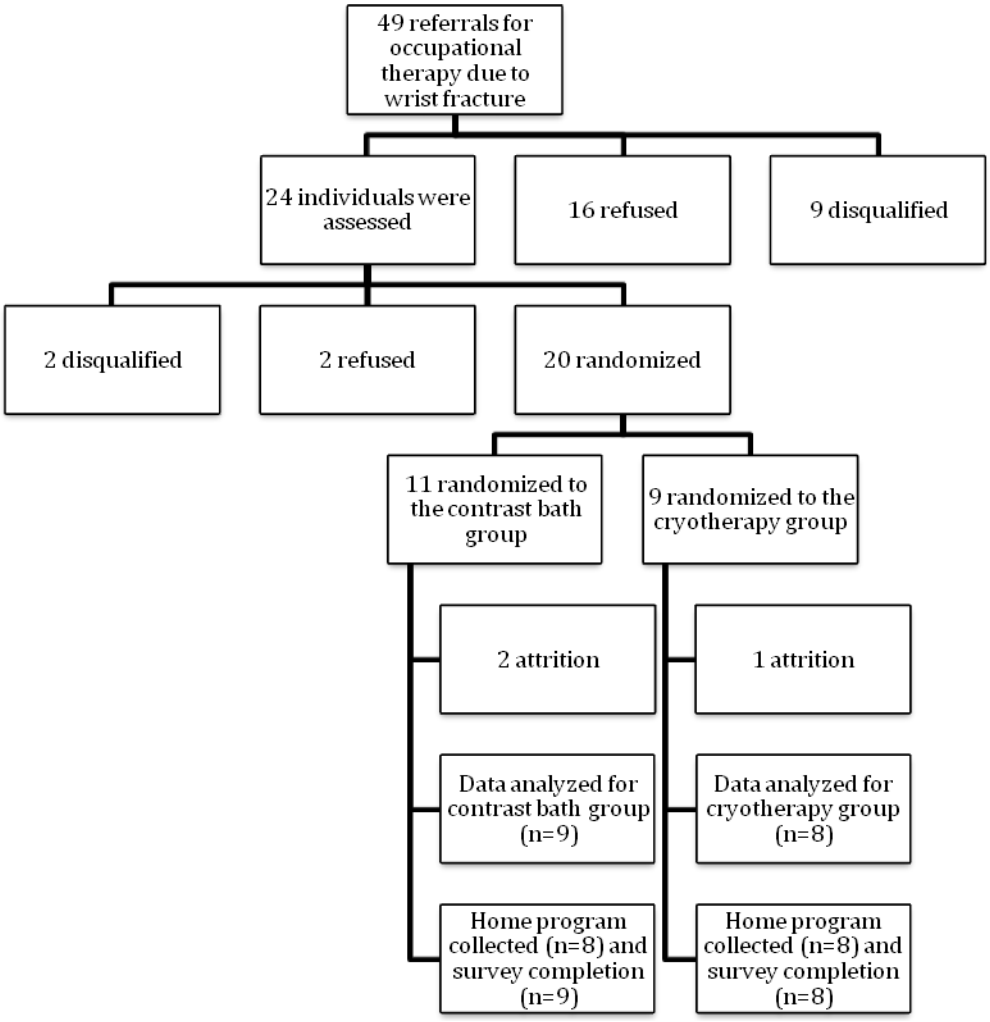


Figure 2. Flow chart of participants from recruitment to completion of the study

Fourteen of the participants were female and six were male (Table 1). Ten participants had a right wrist fracture and nine had a left wrist fracture. The age range for the participants was between 38 and 80 years, with a mean age of 60.8 (*SD* = 11.04) for the cryotherapy group and 56.7 (*SD* = 11.53) for the contrast baths group. Ten participants had surgery prior to therapy. Of those 10 participants, two were randomly assigned to the cryotherapy group and eight were assigned to the contrast baths group. The cryotherapy group had a range of surgery days elapsed (from initial injury) of two to nine days, with a mean of 5.5 days (*SD* = 4.95) and the contrast baths group had the range of days elapsed from one to 21, with a mean of 11 days (*SD* = 6.51). The cryotherapy group had an average of 51.3 (*SD* = 7.28) days between injuries to initial evaluation. The contrast baths group had an average of 50.73 days (*SD* = 23.36) (range of 20 to 88 days). The cryotherapy group had an average of 26.63 (*SD* = 3.07) days of therapy and the contrast baths group had an average of 25.88 (*SD* = 2.32) days of therapy.

Table 1

Demographic Data

	Cryotherapy (*n* = 9)	Contrast Baths (*n* = 11)
Female/Male	5/4	9/2
Right/Left	5/4	5/6
Age	60.8 (11.04)	56.7 (11.53)
Surgery/no Surgery	2/7	8/3
Days from Injury→Surgery	5.5 (4.95)	11 (6.51)
Days from Injury→Eval.	51.33 (7.28)	50.7 (23.36)
How many days of therapy	26.63 (3.07)	25.88 (2.32)

Note. Eval. = evaluation.

The contrast baths group had an attrition of two participants: one participant did not return to therapy and one participant withdrew because she was concerned she was not being provided with the best treatment after group assignment. The cryotherapy

group had an attrition of one participant who did not return to therapy. The researchers analyzed the data from the remaining nine participants in the contrast baths group and the eight in the cryotherapy group. All participants completed the post-study survey. However, a participant from the contrast baths group did not return the home program log. Hence, 16 home program logs were collected for analysis.

Independent samples t-tests were conducted to test for homogeneity between the contrast baths and the cryotherapy groups. Two independent samples t-tests compared the therapy days between the groups and the surgery days elapsed between the groups. The results of the first t-test revealed that there was no statistical difference from the day of injury to the first day of therapy between groups $t(12.11) = 0.24.$, $p < .05$. The results of the second t-test revealed there was no statistical difference from the day of injury elapsed to the day of surgery between groups $t(6) = 0.18$, $p < .05$. In this regard the groups were found to be homogenous.

Independent samples t-tests were also conducted to see if there were differences in therapeutic gains between patients who underwent surgery and patients who did not undergo surgery before therapy. There was no statistical difference between surgery and no surgery in both the contrast baths and cryotherapy groups. A statistically significant mean was found between the eight participants in the cryotherapy group and the nine participants in the contrast baths group ($t(10.88) = 3.228$, $p < .05$).

The researchers used the Pearson Correlation Test to examine if there was a correlation between pain, amount of days elapsed between injury to surgery, and the amount of days from injury to therapy as shown in Table 2. There was a strong positive correlation between surgery days after injury and pain with use in the second week *(r* =

.810, n=8, p < .05). No correlation was found between pain with use and pain with rest (r = -.071, n=17, p > .05). No correlation was found between surgery days elapsed after injury and pain at rest during the second week (r = .124, n=8, p > .5). No correlation was found between days elapsed after injury to the start of therapy and pain at rest (r = .364, n = 17, p > .05) and days elapsed after injury to the start of therapy and pain with use (r = -.245, n = 17, p > .05). Days elapsed after injury to start of therapy and surgery had no correlation as well (r = -.281, n = 8, p > .05).

Table 2

Pearson Correlation Results for Pain at Rest, Pain with Use, Days from Injury to Surgery and Days from Injury to Start of Therapy

		Pain At Rest	Pain With Use	Elapsed Days to Surgery After Injury
Pain With Use	Pearson Correlation	-.071		
	Sig. (2-tailed)	.786		
	N	17		
Days Elapsed After Injury to Surgery	Pearson Correlation	.124	.810	
	Sig. (2-tailed)	.771	.015	
	N	8	8	
Days Elapsed After Injury to the Start of Therapy	Pearson Correlation	.364	-.245	-.281
	Sig. (2-tailed)	.151	.344	.501
	N	17	17	8

Note. Sig. = Significance probability

A factorial ANOVA analysis was conducted to control for a Type 1 error, since the researchers used repeated measurements. The ANOVA showed a statistical significance in improvements in both groups except volumeter and palm circumferences. Specifically the ANOVA for palm circumference was $F(1, 15) = 0.675$, $p = .424$. The ANOVA for the volumeter was $F(1, 14) = 0.348$, $p = .565$. All of the other measurements had a p value of less than .05 for intra-group measurements. The ANOVA revealed that there were statistical changes within both groups from the initial evaluation to the final

assessment for within groups. The ANOVA for between groups showed that there were no statistical differences between contrast baths and cryotherapy.

Home Program Adherence

The participants in this study were asked to keep a home program log to record the number of times that they were able to complete the assigned modality home program (Appendix J). Only 16 participant's home program logs were analyzed because one participant in the contrast baths group did not return her home program log. The participants were instructed by their therapist to perform their assigned home program twice per day. Hence, the researchers considered adherence as two times a day. Of the 16 participants that returned the home program log, only one participant was considered to be adherent by this standard. Another participant was asked by her physician to stop half way through the study due to a diagnosis of tendonitis. She was able to resume her home program after stopping for a total of seven days. Therefore the researchers did not consider this participant non-adherent.

The home programs spanned from 22 to 31 days. A mean frequency value per participant was calculated. After getting an overall average for each individual, the researchers found that most of them were adherent. The adherence for the contrast baths group had a mean value of 2.03 (*SD = 0.*76) times per day and the compliance for icing was 1.75 (*SD* = 0.98) times per day.

At the final measurement appointment, the participants were asked to complete a survey indicating their satisfaction of the assigned home program (Appendix K). The survey consisted of a Likert scale from one to five, one being a less favorable outcome and five being a more favorable outcome. In this subjective survey, the researchers were

interested in understanding the participants' experience with their home modality. The results indicated that the cryotherapy group found icing to be very easy and very comfortable to apply. The participants felt that they were able to do icing twice a day. They also found that icing was somewhat effective. The results for the contrast baths group indicated that this modality was somewhat easy to use and was very comfortable. The participants also reported that they could do contrast baths twice a day. They also found that it was somewhat effective. The results from these surveys showed that the participants in both groups had a similar experience with their modalities, except for the ease of use.

Discussion and Limitations

Discussion

The researchers used a RCT to compare edema management using contrast baths versus cryotherapy in individuals with a distal wrist fracture. Statistical analysis was used to answer the two research questions:

1. Are contrast baths as effective as cryotherapy in reducing edema to improve hand function after a distal wrist fracture?

This research question has a two-part null hypothesis, which stated that a) cryotherapy is more effective than contrast baths in reducing edema with distal wrist fractures and b) cryotherapy is more effective than contrast baths in improving hand function for individuals with a distal wrist fracture. The results show that there were statistical changes for both modalities indicating that the participants in both the contrast baths and cryotherapy groups showed improvement in symptoms. The results of this study suggest that both modalities

are effective in improving hand function after a wrist fracture. Contrast baths are as effective as cryotherapy in improving hand function after a wrist fracture. Therefore, we do not reject the first null hypothesis, which stated that cryotherapy is more effective than contrast baths in reducing edema with distal wrist fractures. Alternatively, we reject the second null hypothesis and accept the alternative hypothesis, which stated that contrast baths are as effective as cryotherapy in improving hand function for individuals with distal wrist fractures.

2. Do contrast baths when compared to cryotherapy, have a similar home program adherence?

Our null hypothesis stated that cryotherapy has better home program adherence than contrast baths. The results of this study found that adherence for contrast baths and icing were similar and that the participants had similar experiences. These results were different from what the researchers had originally anticipated. The researchers had anticipated that adherence in the icing group would be greater due to the ease of use with this modality when compared to the contrast baths. After analyzing the results, convenience of completing the home program may not have as large of an effect on adherence. From the results, the researchers now understand that many factors in the environment impact the person aspect of the fit in the PEO. Motivation was an important factor because the participant's wrist fracture affects his or her occupational participation. Participants' desire to feel better, and when they were given an active role, as with the home program, they were more likely to comply regardless of the convenience factor of their assigned modality. In essence, individuals who noticed improvements with initial use and felt that the treatment was effective were also more likely to adhere to the

program. According to the PEO model, the therapist belongs in the environment category. The occupational therapist plays an important role in home program adherence. The individual may view the therapist as an authoritative figure and may trust that the occupational therapist's advice will help them. This phenomenon may be similar to an exploratory study performed by Boutin-Lester and Gibson (2002), which found that participants who received home health care valued the advice they received from their occupational therapists. The participants viewed the occupational therapist as a friend and a professional, which encouraged them to follow their assigned home program. Another factor that the researchers took into consideration is that the participants in this study might have reported more adherence to the home program because of the Hawthorne effect. The Hawthorne effect occurs when participants perform better on an assignment because they know that they are being observed or that they are a part of a study (Portney & Watkins, 2009). In this study, the participants may have been more adherent to their home program than they typically would have been because they were included in a study.

After reviewing the home adherence data it was noted that there were two participants from the cryotherapy group that significantly brought down the mean average for home program adherence average for the group. If the researchers considered these two participants to be outliers and therefore removed their home program data from the analysis, the cryotherapy home adherence mean increased to over two times per day, which is considered to be adherent.

Participants had the opportunity to leave their subjective experiences on the post-study survey. Out of the 17 participants, only three provided additional comments. Two

of the participants who provided comments were from the contrast baths group and one was from the icing group. Participants A and B in the contrast baths group stated, "Difference in water temperature surely helped movement in the first two weeks." and "Time commitment at four times a day…had to fit in…beneficial for encouraging movement. Would had liked to add icing." Participant C from the icing group reported, "The icing has been very beneficial for the pain, swelling, and numbness." These subjective comments led the researchers to believe that the participants in both groups had positive experiences with their assigned home program.

There was a correlation between days elapsed from injury to surgery and pain with use in the second week. This indicates that the greater the amount of days elapsed between injury and surgery, the greater the pain in the second week of therapy. This is possibly due to having surgery prolonged, which re-injures the soft tissue in the area and disrupts the healing process. When the individual undergoes surgery, the area was reinjured and the participant may therefore experience more pain in the beginning of the therapy.

The results indicated that there were statistical significances in improvement for both groups except in volumeter and palm circumferential measurements. The possible inconsistencies with the palm circumferential measurements could be because the swelling might have occurred in other locations like the fingers or wrist and forearm and not necessarily in the palm. As shown by the results, there was a significant difference with the wrist circumferential measurement. Another possible contributing factor could have been inter-rater reliability. Multiple assessors took the measurements and even though the blind assessors followed the ASHT measuring protocol there may have been

inconsistencies with how the measurements were taken and read. The margin of error for circumferential measurements is 0.25 of an inch. The inter-rater reliability for the wrist is .97 to .98 and there is no inter-rater reliability value reported for the palm circumferential measurement (Taylor et al., 2006). Because of this margin of error, the palm and wrist circumferential measurements may not represent the effect of the modalities on wrist and palm circumferences.

As for the volumeter measurements, we also did not find statistical significant results in the use of cryotherapy nor contrast baths. The possible discrepancies for the volumeter measurements could also be due to the time of day that the participants were being measured. It is possible that the participants may have experienced more swelling later in the day than they would have in the morning. Therefore, if a participant was measured at different times of the day throughout the course of the study the data may be inconsistent. Lastly, the participants may have leaned into the volumeter more than others. For instance, some might have leaned onto their arm in the volumeter while others did not. This would have caused more displacement of water from the volumeter than would have occurred if the participant did not lean into the volumeter. The margin of error for the volumeter measurement using the displacement method is 10 millimeters, which may have skewed the results for this study (Wehbe, 1987).

The researchers also observed a trend with the results from the cryotherapy and contrast baths groups (Figure 3). The contrast baths group seemed to have a greater improvement in the first two weeks and then tapered off in the last two weeks. The cryotherapy group had a more gradual increase throughout the four weeks. This may

indicate that contrast baths may have more of an effect in the first two weeks than cryotherapy but overall they are just as effective over a period of four weeks.

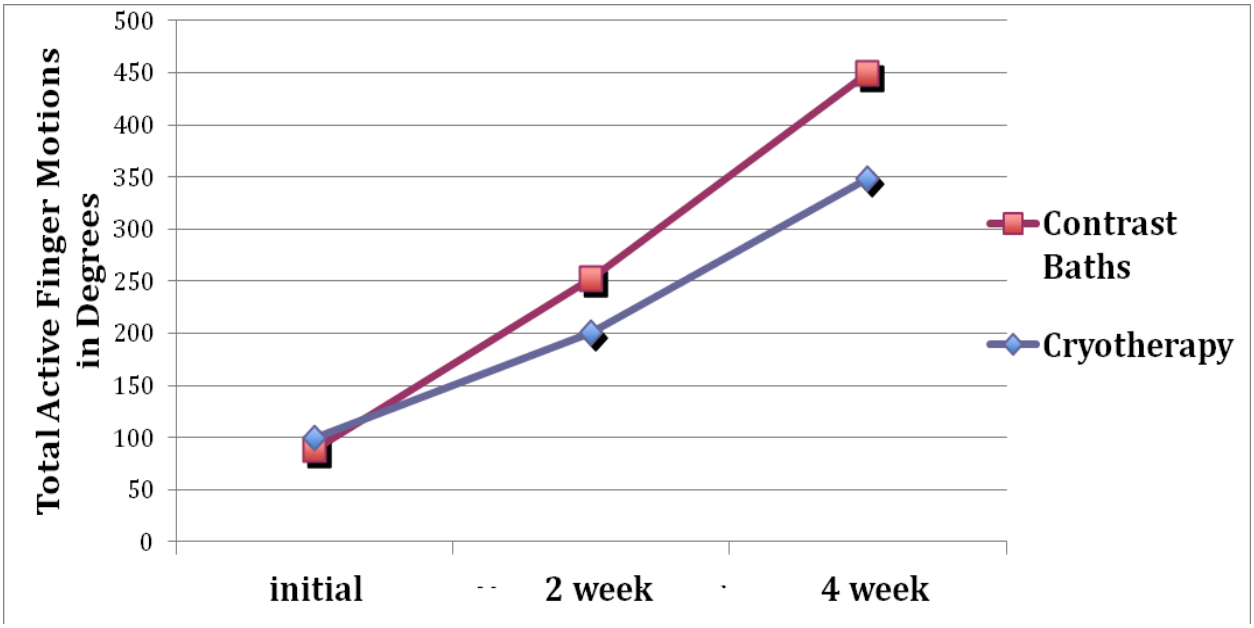


Figure 3. Trends of Improvement for the Measurement of Total Active Finger Motions for Both Contrast Baths and Cryotherapy

Limitations

Some of the limitations included several assessors were used because of the required multiple re-measurements and the length of the study. Multiple assessors affected the inter-rater reliability, which may have accounted for variations in the data from initial assessment, the 2nd week and 4th week data. To address this potential threat, attempts were made to assign each participant to a specific assessor to make sure that the same assessor carried out the three measurements. Nevertheless, it was not possible to have each participant measured by the same assessor each time.

This study included participants with distal ulnar and/or radial fractures. Therefore, there was a chance that there were differences in individuals who sustained one fracture over another, or fractures of both bones. There may have also been a

difference because a fracture of both the forearm bones may cause more trauma than a fracture of only one of the bones, which also may increase the healing time. This might have impacted the effectiveness of the modalities provided. To address this problem, the researchers randomly assigned the participants to the various home programs using a Microsoft Excel randomization sheet (Appendix A) in order to create homogeneous groups.

The time of day that the participant was measured or received the modality/intervention may have affected the results of the study. Participants were measured at different times of the day depending on their scheduled time for hand therapy. Some individuals may have experienced more swelling at different times of the day. For instance an individual may experience more swelling in the morning than in the afternoon. If a client was measured at different times of the day throughout the course of this study the measurements may not have been consistent due to the changes in swelling during the course of the day.

Another possible limitation of this study included multiple therapists treated the participants. There was not an assigned therapist to each participant throughout the course of the study. Different treating therapists may have affected the participants' therapeutic gains. On the other hand, all therapists at Mills-Peninsula Health Services have been working together for minimum of seven years and therefore have established similar intervention approaches to maintain continuity of intervention.

This study contained a small sample size. Because of the small sample size the true effect of the intervention may not been detected accurately. This is a limitation

because the actual affect that contrast baths or cryotherapy had on the participants may not have been shown with the small number of participants.

Summary, Conclusion and Recommendations

Wrist fractures account for almost one fifth of all emergency room visits and surgeries performed in the United States (Voda, 2011). Distal radius and/or ulnar fractures account for the most common type of wrist fractures. Edema, which occurs after an onset of an injury, can be problematic because it decreases ROM, which decreases strength and hand function (Klein, 2007). The most common modality used to treat edema is cryotherapy. Cryotherapy is the application of cold to the injury to reduce edema and pain. Another common modality used by 70% of hand therapists is contrast baths, which requires alternating the hand in warm and cool water baths to facilitate normal vasoconstriction and vasodilation (Wilcock, Cronin, & Hing, 2006). Despite the fact that therapists find contrast baths to be a useful modality, there is little evidence available to support its effectiveness.

This study evaluated the effectiveness of contrast baths compared to cryotherapy in reducing edema and improving hand function for individuals with a distal wrist fracture. The researchers found that contrast baths are as effective as cryotherapy in improving function. Both groups showed statistical improvements from the initial evaluation to the final evaluation. Through observational trends the researchers noted that the contrast baths group had a larger effect in the first two weeks of treatment, while the cryotherapy group had more gradual improvements over the four-week period of the study. This information can help occupational therapists determine an appropriate home modality for their patients with a wrist fracture. This study also evaluated if there was

similar home program adherence for participants in either group. The researchers found that adherence for contrast baths was similar to cryotherapy. The post-study survey showed that individuals in either group had positive experiences with either modality. The clinical implications for this study provide evidence for the continued use of contrast baths in the treatment of decreased hand function due to a distal wrist fracture. This study contributes to the practice of occupational therapy by providing more evidence to support the use of contrast baths as another option in the treatment of decreased hand function due to a wrist fracture. By providing occupational therapists with another option to treat wrist fractures this will allow for increased functional improvements for clients. It is our hope that this study has added additional evidence to support the use of contrast baths.

The field of occupational therapy would benefit from further research on the effectiveness of contrast baths as an adjunct modality. This study was limited to only individuals with a diagnosis of a distal wrist fracture. Future studies would benefit from investigating the effectiveness of contrast baths with different diagnoses. Also, additional studies would benefit from obtaining a larger sample size. A larger sample size would strengthen the overall evidence level. The researchers also took into consideration that participants in this study may or may not have had surgery. A future study would benefit from further exploring the effects of surgery on the effectiveness of contrast baths. Additionally, more research is needed on specific protocols such as temperature, time and duration, regarding contrast baths and the effect it has on edema.

This study adds to the profession of occupational therapy by providing research to support the use of contrast baths in the treatment of edema in order to restore hand function. This study gives therapists more evidence to support the use of contrast baths in

improving hand function after a distal wrist fracture. By facilitating improvements in hand function, a therapist is able to improve the individual's participation in occupations.

References

Alitzer, L. L. (2008). Colles' fracture. *Orthopaedic Nursing, 27*(2), 140-147

American Occupational Therapy Association. (2010). Occupational therapy code of ethics and ethics standards. *American Journal of Occupational Therapy*, 64(Suppl.), S17-S26. doi: 10.5014/ajot.2010.64S17

American Occupational Therapy Association. (2008). Occupational therapy practice framework: Domain and process (2nd ed.). *American Journal of Occupational Therapy, 62*, 625–683.

Apfel, E., Johnson, M., & Abrams, R. (2002). Comparison of range-of-motion constraints provided by prefabricated splints used in the treatment of carpal tunnel syndrome: A pilot study. *Journal of Hand Therapy, 15*(3), 226-233. doi: 10.1016/S0894-1130(02)70005-7

Artzberger, S. (2007). Edema reduction techniques: A biological rationale for selection. In C. Cooper. *Fundamentals of hand therapy: Clinical reasoning and treatment guidelines for common diagnoses of the upper extremity* (pp. 36-52). St. Louis: Mosby Elsevier.

Bamford, R. & Walker, D. (2010). A qualitative investigation into rehabilitation experience of patients following wrist fracture. *Hand Therapy*, *15*(3), 54-61. doi:10.1258/ht.2010.010013

Bialoszewski, D., Wozniak, W. & Zarek, S. (2009). Clinical efficacy of kine-siology taping in reducing edema of the lower limbs in patients treated with the ilizarov method. *Ortop Traumatol Rehabilitation,11*(1), 46–54.

Bijur, P. E., Silver, W. & Gallagher, E. J. (2001). Reliability of the visual analog scale for measurement of acute pain. *Academy of Emergency Medicine, 8*(12), 1153-1157.

Bleakley, C., McDonough, S. & MacAuley, D. (2004). The use of ice in treatment of acute soft-tissue injury: A systematic review of randomized controlled trials. *American Journal of Sports Medicine*, *32*, 251-261.

Boutin-Lester, P. & Gibson, R. W. (2002). Patients' perceptions of home health occupational therapy. *Australian Occupational Therapy Journal, 49*, 146-154.

Breger Stanton D., Bear Lehman J., Graziano M., & Ryan C. (2003). Contrast baths: What do we know about their use? *Journal of Hand Therapy*,*16*, 343-346. doi:10.1197/S0894-1130(03)00161-3

Breger-Stanton, D., Lazaro, R., & MacDermid, J. C. (2009). A systematic review of the effectiveness of contrast baths. *Journal of Hand Therapy, 22*(1), 57-70. doi: 10.1016/j.jht.2008.08.001

Brienes, E. B. (2012). Therapeutic occupations and modalities. In H. Pendelton & Schultz-Krohn (7th Ed.), Occupational therapy: Practice skills for physical dysfunction (pp. 729-754). St Louis: Mosley Elsevier.

Brodeur-Lyons, S., & Oakes, M. W. (2009). It's all in the hands. *Rehab Management: The Interdisciplinary Journal of Rehabilitation, 22*(3), 18-21.

Chesterton, L., Foster, N. & Ross, L. (2002). Skin temperature response to cryotherapy. *American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation*, *83*, 543-549. doi:10.1053/apmr.2002.30926

Cochrane, D. (2004). Alternating hot and cold water immersion for athlete recover: A

review. *Physical Therapy in Sports, 5*(1), 26-32. doi: 10.1016/j.ptsp.2003.10.002

Cole, M. & Tufano, R. (2008a). Biomechanical and rehabilitative frames. In M. Cole and R. Tufano (Eds.), *Applied Theories in Occupational Therapy: A Practical Approach* (pp.165-174). Thorofare, NJ: Slack Incorporated.

Cole, M. & Tufano, R. (2008b). Person-environment-occupational-performance-model. In M. Cole and R. Tufano (Eds.), *Applied Theories in Occupational Therapy: A Practical Approach* (pp.127-134). Thorofare, NJ: Slack Incorporated.

Contrast Baths, In *Merriam-Webster.com*. Retrieved September 11, 2012, from http://www.merriam-webster.com/dictionary/contrastbaths.

Cryotherapy, In *Merriam-Webster.com*. Retrieved September 11, 2012, from http://www.merriam-webster.com/dictionary/cryotherapy.

DeLoach, L. J., Higgins, M. S., Caplan, A. B. & Stiff, J. L. (1998). The visual analog scale in the immediate postoperative period: Intrasubject variability and correlation with a numeric scale. *International Anesthesia Research Society*, *86*, 102-106.

Dodds, R., Nielsen, K., Shirley, A., Stefaniak, H. & Moyers, P. (2004). Test-retest reliability of the commercial volumeter. *Medline, 22*(2), 107-110.

Dunbar, S. B. (2007). Occupational therapy models for intervention with children and families. Thorfare, New Jersey: Slack Incorporated.

Dykstra, J. H., Hill, H. M., Miller, M. G., Cheatham, C. C., Michael, T. J. & Baker, R. J. (2009). Comparisons of cubed ice, crushed ice, and wetted ice on intramuscular and surface temperature changes. *Journal of Athletic Training*, *44*(2), 136-141.

Edema. 2012. In *Merriam-Webster.com*. Retrieved September 11, 2012, from

http://www.merriam-webster.com/dictionary/edema.

Ellis, B., & Bruton, A. (2002). A study to compare the reliability of composite finger flexion with goniometry for measurement of range of motion in the hand. *Clinical Rehabilitation, 16*(5), 562-570. doi: 10.1191/0269215502cr513oa

Engstrand, C., Krevers, B., & Kvist, J. (2012). Interrater reliability in finger joint goniometer measurement in dupuytren's disease. *American Journal of Occupational Therapy, 66*(1), 98-103. doi: 10.5014/ajot.2012.001925

Goniometer, In *Merriam-Webster.com*. Retrieved September 11, 2012, from http://www.merriam-webster.com/dictionary/goniometer.

Haren, K., Wilberg, M. (2006). A prospective randomized controlled trial of manual lymph drainage (MLD) for the reduction of hand oedema after distal radius fracture. *The British Journal of Hand Therapy*, *11*(2), 41-47.

Helsel, P. & Graveline, C. (2001). Physical management of spasticity. *Journal of Child Neurology*, *16*(24), 24-30. doi: 10.1177/088307380101600105

Irdesel, J., & Çeliktas, S. (2007). Effectiveness of Exercise and Compression Garments in the Treatment of Breast Cancer Related Lymphedema. Turkish Journal Of Physical Medicine & Rehabilitation / Turkiye Fiziksel Tip Ve Rehabilitasyon Dergisi, 53(1), 16.

Janssen, R. G., Schwartz, D. A., & Velleman, P. F. (2009). A randomized controlled study of contrast baths on patients with carpal tunnel syndrome. *Journal of Hand Therapy, 22*(3), 200. doi: 10.1016/j.jht.2009.02.001

Kanlayanaphotporn, R., & Janwantanakul, P. (2005). Comparison of skin surface

temperature during the application of various cryotherapy modalities. *Archives of Physical Medicine & Rehabilitation, 86*(7), 1411-1415. doi: 10.1016/j.apmr.2004.11.034

Kasch, M. C. & Walsh, J. M. (2012). Hand and upper extremity injuries. In H. Pendelton & Schultz-Krohn (7th Ed.), Occupational therapy: Practice skills for physical dysfunction (pp. 1037-1073). St Louis: Mosley Elsevier.

Klein, L. (2007). Evaluation of the hand and upper extremity. In C. Cooper (1st Ed.), Fundamentals of Hand Therapy: Clinical Reasoning and Treatment Guidelines for Common Diagnoses of the Upper Extremity (pp. 73-97). St Louis: Mosley Elsevier.

Leahy, M. (2011). Early skeletal fragility not easy to spot. *American Academy of Orthopedic Surgeons*. Retrieved from http:www.aaos.org/news/aaosnow/nov11/clinical2.asp

Lewis, S. C. (2003). Physical disabilities and occupational therapy intervention approaches. In S.C. Lewis, Elder Care in Occupational Therapy (pp. 183-250). Thorofare: Slack Incorporated.

Lindstron-Hazel, D., Kratt, A. & Bix, L. (2009). Interrater reliability of students using hand and pinch dynamometers. *The American Journal of Occupational Therapy*, *63*(2), 193-197. Retrieved from http://ajot.aotapress.net/content/63/2/193.full.pdf

Lyngcoln, A., Taylor, N., Pizzari, T. & Baskus, K. (2005). The relationship between adherence to hand therapy and short-term outcome after distal radius fracture. *Journal of Hand Therapy*, *18*, 2-7. doi: 10.1197/j.jht.2004.10.008

McMillan, R. (2002). Assumptions Underpinning a Biomechanical Frame of Reference in Occupational Therapy. In E. Duncan (ed), *Foundations for Practice in Occupational Therapy*. London: Elsevier Limited. pp. 255-275

Mills-Peninsula Health Services. (2012). About us. Retrieved from http://www.mills-peninsula.org/about/

Oyen, J., Brudvik, C., Gjesdal, C. G., Tell, G. S., Lie, S. A. & Hove, L. M. (2011). Osteoporosis as a risk factor for distal radius fractures: A case-control study. *The Journal of Bone and Joint Surgery, Incorporated*, *93-A*(4), 348-356. doi:10.2106/JBJS.J.00303

Portney, L. & Watkins, M. (2009). Foundations of clinical research: Applications to practice (3rd ed.). New Jersey: Pearson, Prentice Hall.

Priganc, V. & Ito, M. (2008). Changes in edema, pain, or range of motion following manual edema mobilization: A single case study. Journal of Hand Therapy, 21, 326-335. doi:10.1197/j.jht.2008.04.005

Putter, C., Beeck, E., Looman, C., Toet, H., Hovius, S. & Selles, R. (2011). Trends in wrist fractures in children and adolescents, 1997-2009. *Journal of Hand Surgery*, *8*(6), 1-6. doi:10.1016/j.jhsa.2011.08.006

Schultz-Krohn, W. & Pendleton, H. (2012). Application of occupational therapy practice framework to physical dysfunction. In H. Pendelton & Schultz-Krohn (7th Ed.), Occupational therapy: Practice skills for physical dysfunction (pp. 28-54). St Louis: Mosley Elsevier.

Shechtman, O., Gestewitz, L. & Kimble, C. (2005). Reliability of the Dynex dynamometer. *Journal of Hand Therapy*, *18*(3), 339-346. doi:10.1197/j.jht.2005.04.002

Shih, C., Lee, W., Huang, C. & Wu, Y. (2012). Effect of time ratio of heat to cold on brachial artery blood velocity during contrast baths. *Physical Therapy Journal, 92*(3), 448-453. doi:10.2522/ptj.20100394

Souer, J. S., Buijze & Ring, D. (2011). A prospective randomized controlled trial comparing occupational therapy with independent exercises after volar plate fixation of a fracture of the distal part of the radius. *The Journal of Bone and Joint Surgery, Incorporated*, *93*(1) 1761-1766. doi: 10.2106/JBJS.J.01452

Sran, M. M., Stotz, P. J., Normandin, S. C., & Robinovitch, S. N. (2010). Age differences in energy absorption in the upper extremity during a descent movement: Implications for arresting a fall. *Journals of Gerontology Series A: Biological Sciences & Medical Sciences, 65*(3), 312-317. doi: 10.1093/gerona/glp153

Operational Manual (2001). *Touch test sensory evaluators: Semmes Weinstein Von Frey aesthesiometers*. Woodale, IL: Stoelting Co. Taylor, B. & Attia, M. (2000). Sport-related injuries in Children. *Sport Injuries*, *7*(12), 1376-1382.

Taylor, R., Jayasinghe, U., Koelmeyer, L., Ung, O. & Boyages, J. (2006). Reliability and validity of arm volume measurements for assessment of lymphedema. *Journal of the American Physical Therapy Association*, *86*(2), 205-214. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16445334

Villeco, J. P. (2012). Edema: A silent but important factor. *The Journal of Hand Therapy*, *25*(221), 153-162. doi:10.1016/j.jht.2011.09.008

Voda, S., C. (2011). Bad breaks: A nurse's guide to distal radius fractures. *Nursing, 41*(8), 34-41. doi: 10.1097/01.NURSE.0000399599.97411.cb

Volumeter, In *Merriam-Webster.com*. Retrieved September 11, 2012, from http://www.merriam-webster.com/dictionary/volumeter.

Walsh, C. R. (2012). Wrist in the young and elderly. *OR Nurse Journal*, *6*(3), 28-38.

Wehbe, M. (1987). Tendon gliding exercises. *American Journal of Hand Therapy*, *41*(3), 164-167.

Wilcock, I. M., Cronin, J. B., & Hing, W. A. (2006). Physiological response to water immersion: A method for sport recovery? *Sports Medicine, 36*(9), 747-765.

Zuther, E. Z. (2009). Treatment. In E. Z. Zuther (Ed.), Lymphedema management (2nd E) (pp.143-246). New York, NY: Thieme

Appendix A
Microsoft Randomization Table

1 Set of 100 Unique Numbers Per Set
Range: From 0 to 99 -- Unsorted
Set 1

97	24	25	89	43	32	76	44	38	99
08	40	35	94	51	41	83	95	42	81
01	14	18	29	90	85	10	75	68	11
52	49	39	19	84	47	54	82	21	74
63	23	72	59	00	93	64	04	56	06
07	34	53	02	87	26	67	33	37	69
92	30	05	71	15	09	45	55	79	03
31	36	77	66	16	17	73	13	88	27
12	20	96	60	46	86	98	65	58	50
62	22	70	57	78	61	48	28	91	80

Appendix B
Letters for Permission to Conduct a Research Study

11/10/12
Mills Peninsula Hospital
100 South San Mateo Drive
San Mateo

Re: Permission to conduct a research study

We, Brittany Phipps and Elizabeth Brown, are writing to request permission to conduct a research study at Mills Peninsula Hospital. We are currently enrolled in the Masters of Science in Occupational Therapy at Dominican University of California in San Rafael, CA. We are in the process of writing our Master's Thesis on the effectiveness of contrast baths on reducing edema after a wrist fracture. Our Master's Thesis is under the guidance of our advisor, Kitsum Li OTD, OTR/L.

After approval from IRB, we hope to recruit 20 participants, both men and women, who are referred to the hand therapy clinic because of a recent distal radius and/or ulna fracture. The participants will be asked to come 30 minutes early, so that the blinded assessors will complete an evaluation on both the affected and unaffected hand. The participants will receive their regularly scheduled therapy appointment. The participants will be re-measured two weeks and four weeks after their initial measurement but this time will only need to come in 15 minutes early to measure only the affected hand. Patients who are interested in participating in the study will be given a consent form to sign, along with a patient's bill of rights.

If approval is granted, we are hoping to use the patients that are referred to Mills Peninsula hand therapy clinic in our study. An approval to conduct this study will be greatly appreciated. We will be happy to answer any questions or concerns that you have at this time. You may contact us at either brittany.phipps@students.dominican.edu or elizabeth.brown@students.dominican.edu or our thesis advisor, Dr. Kitsum Li (kitsum.li@dominican.edu).

Sincerely,

Brittany Phipps, OTS and Elizabeth Brown, OTS
Dominican University of California

Dr. Kitsum Li, OTD, OTR/L, Thesis Advisor

I agree with the above request,

_____ _____
Signature Date

11/10/12
(Insert doctor's name)
(Insert doctor's address)

Re: Permission to conduct a research study

We, Brittany Phipps and Elizabeth Brown, are writing to announce a research study with patients that you refer to Mills Peninsula Hospital. We are currently enrolled in the Masters of Science in Occupational Therapy at Dominican University of California in San Rafael, CA. We are in the process of writing our Master's Thesis on the effectiveness of contrast baths on reducing edema after a wrist fracture. Our Master's Thesis is under the guidance of our advisor, Kitsum Li OTD, OTR/L.

We hope to recruit 20 participants, both men and women, who are referred to the hand therapy clinic because of a recent distal radius and/or ulna fracture. The participants will be asked to come 30 minutes early, so that the blinded assessors will complete an evaluation on both the affected and unaffected hand before commencement of therapy. The participants will be randomly assigned to either contrast baths or cryotherapy for their home program modality. The participants will then receive their regularly scheduled therapy appointment. The participants will be re-measured two weeks and four weeks after their initial measurement but this time will only need to come in 15 minutes early to measure only the affected hand. Patients who are interested in participating in the study will be given a consent form to sign, along with a patient bill of rights.

We are hoping to use the patients that are referred to Mills Peninsula hand therapy clinic in our study. We will be happy to answer any questions or concerns that you have at this time. You may contact us at either brittany.phipps@students.dominican.edu or elizabeth.brown@students.dominican.edu or our thesis advisor, Dr. Kitsum Li (kitsum.li@dominican.edu).

Sincerely,

Brittany Phipps, OTS and Elizabeth Brown, OTS
Dominican University of California

Appendix C
Phone Screening Script

My name is _____. I am one of the research assistants in the department of occupational therapy at Mills-Peninsula Health Services. I understand that you are referred to us for hand therapy because you have (a wrist fracture/broken your wrist). May I ask you a few questions?

When did the wrist fracture happen? (approximate date is okay)
Which side of your hand is involved in the fracture? (Left or Right)
Other than the wrist fracture did you have any other injury in the (fall, accident)?

We are conducting a research study at the hand therapy department comparing the use of icing and warm/cold water baths in controlling swelling in the wrist and hand after a fracture. Swelling in the wrist and hand are common residual problems after immobilization for healing to occur. Currently, both warm/cold water baths and icing are commonly used as home program for an individual to manage swelling at the wrist and hand. The purpose of this study is to find out which of these two modalities has a faster effect in decreasing swelling and is easier to use as a home program.

To participate in the study, you will meet with one of the assessors first so that we can take some measurements of both your hands and wrists. We want to compare the two sides so that we know how much movements are being affected since you broke your wrist. After the measurements, you will then meet your assigned hand therapist. She will provide you with instruction for you home program to manage your swelling at home. She will also provide you with therapy and teaching to help you regain your movement and function. The treatment you receive will be the same whether you decide to participate or not.

If you agree to participate in this study, I would like to ask you to come about 30 minutes early to your 1st appointment time so that one of the assessors can take the measurements of you. In the 2nd and 4th week, we will re-measure and it will only take 15 minutes before your appointment. Since your measurements are already taken before the therapy session, your therapist will not need to spend time on the measurements again and she can focus on addressing your needs and concerns. This will allow the therapist more time in providing treatment.

In appreciation of your participation you will receive a free exercise putty. Your therapist will issue the free putty to you when she feels that you are ready to do the exercises.

There is no additional cost to you except coming in early to some of the appointments for measurements. Whether you participate or not this will not affect your therapy. Your therapist will always provide you with the best treatment to help you regain your movement and function. But we do ask you to follow your home program and keep a home program log for us. Are you willing to participate in our study?
(Wording is not standardized)

Appendix D
DOMINICAN UNIVERSITY OF CALIFORNIA
CONSENT TO BE A RESEARCH SUBJECT

Purpose and Background

Elizabeth Brown, OTS and Brittany Phipps, OTS are conducting a research study on the effectiveness of contrast baths (warm/cold water immersion) versus cryotherapy (icing) in reducing edema (swelling) in the wrist and hand after a wrist fracture. Swelling in the wrist and hand are common residual problems after immobilization for fracture healing. Currently, both contrast baths and icing are commonly used as a home program for an individual to manage swelling at the wrist and hand. The purpose of this research is to find out which of these two modalities has a faster effect to decrease swelling and is easier to use as a home program.

I am being asked to participate in this study because I am an individual with a recent (between 4-8 weeks) wrist fracture of my dominant or non-dominant arm. I am now ready for post-immobilization hand therapy.

Procedures

If I agree to be a participant in this study the following will happen:

1. I will answer questions from the initial questionnaire to determine if I meet the inclusion criteria for the study.
2. I will participate in the initial measurements, including the volume and circumferences of both hands and wrists and active movements in both wrists, forearms, and all fingers, sensory testing on my fingers using the Semmes-Weinstein Monofilament and pain assessment using the Visual Analog Pain Scale. A trained assessor will complete all of the initial measurements.
3. Upon completion of the initial measurements I will receive a voucher for a theraputty, which I can use to collect my free theraputty when I am ready to use it in my therapy and home program.
4. I will be randomly assigned to either contrast baths or icing as my primary home program to manage my swelling. My treating therapist will provide me with verbal and written instructions of my assigned home program. I will receive a home program log sheet to track my daily home program.
5. My hand therapy interventions will be tailored to my specific conditions and needs and I shall not be treated differently regardless of my group assignment.
6. I acknowledge that I am expected to comply with the home program. I shall be doing the home program to the best of my ability and I shall log my frequency in the home program log sheet daily.
7. If I experience discomfort while doing my assigned home program, I will immediately stop the program and consult my treating therapist at my next appointment.

8. An assessor will reassess my progress at weeks 2 and 4 from the start of my therapy program. The re-assessments will include volume and circumferences of my affected hand and wrist, active movement in the affected wrist, forearm and fingers, and sensory testing on the fingers of the affected hand. A pain assessment will also be administered.
9. I will return the home program log sheet at the 4th week re-assessment to the assessor.
10. I understand that all the measurements taken by the assessor will be shared with my treating therapist(s) and will be documented as part of my therapy treatment record and progress.
11. I will be given a short survey to be completed at my 4th week reassessment. The survey will include questions such as the ease and convenience of my assigned home program and if I experienced any barrier and discomfort performing my assigned home program.
12. I will be provided with a written summary of the findings and conclusions of this project upon my request. These results may not be available for 3 to 6 months after completion of the study in November 2012.

Risks and/or Discomforts

1. I understand that my participation might involve a risk of burn (heat or cold). To minimize this risk of burn with either the use of contrast baths or icing home program, I will receive specific instructions from my therapist on how to test the water baths temperatures before submerging my hand in the water baths, or use a barrier layer between contact of my skin to the frozen gel pack.
2. I understand that temperatures sensitivity and tolerance are subjective to my condition and me. If I feel discomfort with the water temperatures or the frozen gel pack I will discontinue with the program and consult with my treating at my next appointment.
3. I may elect to stop participating in the study at any time and may refuse to participate before or after the study is started without any adverse effects.
4. I will need to arrive 30 minutes early on my initial appointment and then 15 minutes early on my 2nd and 4th weeks reassessment appointments.

Benefits

The primary potential benefit is that I may have decreased swelling, pain, and improvements in movement of my wrist and fingers with consistent use of the assigned home program. I will also be allowed to keep my free theraputty, even if I elect to withdraw early from the study. Another potential benefit of the study is that I will receive increased treatment time with the treating therapist on the days I have reassessments.

Questions

I have talked to the assessor about this study and have had all my questions answered. If I have further questions about the study, I may contact the researchers Elizabeth Brown or Brittany Phipps at (415) 458-3783.

Consent
I have been given a copy of this consent form, signed and dated to keep.

PARTICIPATION IN THIS STUDY IS VOLUNTARY. I am free to decline to be in this study or withdraw my participation at any time without fear of adverse consequences.

My signature below indicates that I agree to participate in this study.

_____ _____
PARTICIPANT'S SIGNATURE **DATE**

_____
PARTICIPANT'S NAME (PRINT)

_____ _____
WITNESS SIGNATURE **DATE**

Description of the assessment tools:
Edema (swelling) will be measured by circumferential measurements of the wrist and palm using a soft measuring tape. A volumeter will be used to measure the volume of the hand by water displacement.

Movements at the wrist, forearm, hand, and fingers will be measured by a goniometer.

Pain will be assessed using the Visual Analog Pain Scale, which is a 10-point scale that rates from 0 (without pain) to 10 (excruciating pain).

Sensation of the hand will be assessed using the Semmes-Weinstein Monofilament test. Four positions of the hand (thumb pad, back of index finger tip, back of little finger tip, and front of ring finger tip) will be used to measure sensory effects of the 3 major nerves in the hand.

Appendix E
RESEARCH PARTICIPANT'S BILL OF RIGHTS

Every person who is asked to be in a research study has the following rights:

1. To be told what the study is trying to find out;

2. To be told what will happen in the study and whether any of the procedures, drugs or devices are different from what would be used in standard practice;

3. To be told about important risks, side effects or discomforts of the things that will happen to her/him;

4. To be told if s/he can expect any benefit from participating and, if so, what the benefits might be;

5. To be told what other choices s/he has and how they may be better or worse than being in the study;

6. To be allowed to ask any questions concerning the study both before agreeing to be involved and during the course of the study;

7. To be told what sort of medical treatment is available if any complications arise;

8. To refuse to participate at all before or after the study is stated without any adverse effects. If such a decision is made, it will not affect h/her rights to receive the care or privileges expected if s/he were not in the study.

9. To receive a copy of the signed and dated consent form;

10. To be free of pressure when considering whether s/he wishes to agree to be in the study.

If you have other questions regarding the research study, you can contact the researchers Elizabeth Brown and Brittany Phipps or their advisor Kitsum Li, at (415) 458-3753. You may also contact The Dominican University of California Institutional Review Board for the Protection of Human Subjects by telephoning the Office of Academic Affairs at (415) 257-0168 or by writing to the Associate Vice President for Academic Affairs, Dominican University of California, 50 Acacia Avenue, San Rafael, CA. 94901

Appendix F
DOMINICAN UNIVERSITY OF CALIFORNIA
MILLS-PENINSULA HEALTH SERVICES
INITIAL QUESTIONNAIRE

CONTRAST BATHS VERSUS CRYOTHERAPY STUDY QUESTIONNAIRE

No. : _____ Today's date: _____

_____Sex: M/F
Full Name Date of Birth (MM/DD/YY)

_____
Type of Wrist fracture (as listed on the referral) Date of injury

Reason for referral: _____

Brief history (including surgical and/or non-surgical intervention for the wrist fracture)

_____

_____

Medical History

_____

_____

Does the individual have any of the following conditions that exclude her/him from the study?
□ Reflex Sympathetic Dystrophy (also known as Shoulder-Hand Syndrome, Causalgia or Complex Regional Pain Syndrome)
□ Tear of the Triangular Fibrocartilage Complex (TFCC), as indicated in the referral
□ Open wound presence at the site of injury
□ Existence of external fixator or external pins
□ Nerve injury, as indicated in the referral

The individual fulfills the inclusion criteria for the study
□ Yes □ No
The individual received fall prevention education
□ Yes □ No
The individual received a voucher for theraputty

□ Yes □ No

MEASUREMENTS NO. _____

Affected Side: _____

Initial assessment date	2-week reassessment week of	4-week assessment week of

RANGE OF MOTION

Date	Right	Left	R / L	R / L
Wrist: Extension				
Flexion				
Radial Deviation				
Ulnar Deviation				
Forearm: Supination				
Pronation				

TOTAL FINGER ACTIVE MOVEMENT

Date		Right			Left			R / L			R / L		
		ext	**flex**	**total**	**ext**	**flex**	**total**	**ext**	**flex**	**total**	**ext**	**flex**	**total**
Thumb	Abd												
	MC												
	IP												

Index	MP												
	PIP												
	DIP												
Middle	MP												
	PIP												
	DIP												
Ring	MP												
	PIP												
	DIP												
Little	MP												
	PIP												
	DIP												

No: _____

EDEMA MEASUREMENTS

Date	**Right**	**Left**	**R / L**	**R / L**
Palm (inch)				
Wrist (inch)				
Volumeter				

STRENGTH

Date	**Right**	**Left**	**R / L**	**R / L**
Grip				
Lateral				
2-point				
3-point				

PAIN ASSESSMENT

Date:

Location:

Frequency: constant, frequent, intermittent, occasional

Type/Quality:

Medications:

Pain Rating at Rest:

for Use:

Factors that Affect Pain:

Factors that Relieve Pain:

Date:

Location:

Frequency: constant, frequent, intermittent, occasional

Type/Quality:

Medications:

Pain Rating at Rest:

for Use:

Factors that Affect Pain:

Factors that Relieve Pain:

Date

Location:

Frequency: constant, frequent, intermittent, occasional

Type/Quality:

Medications:

Pain Rating at Rest:

for Use:

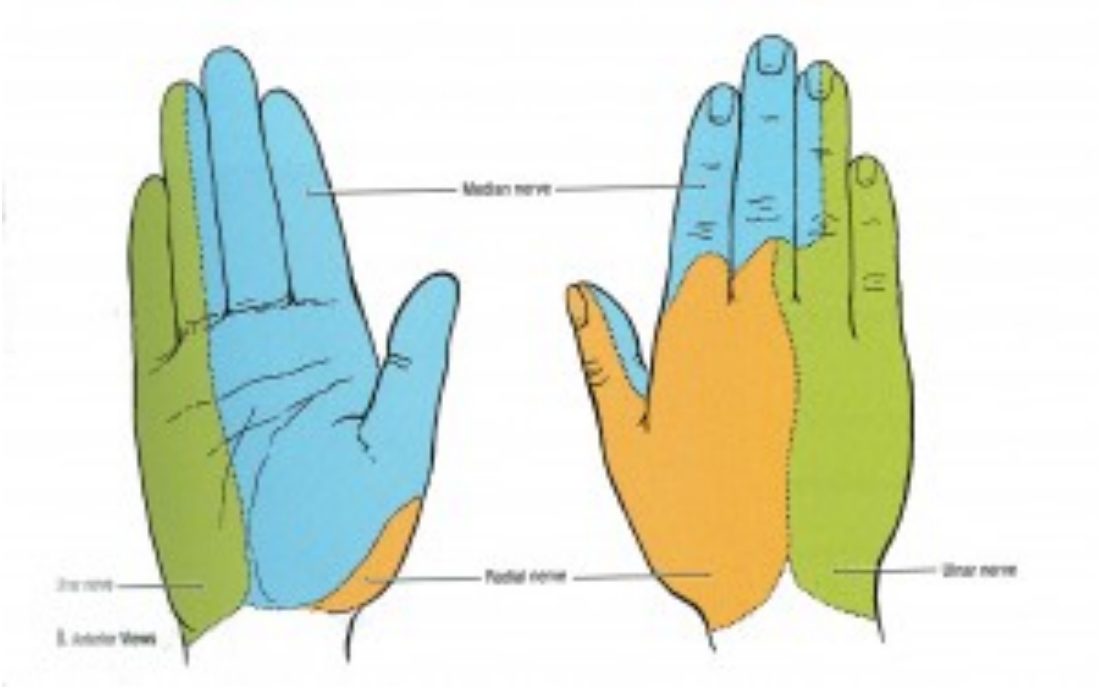
Factors that Affect Pain:

Factors that Relieve Pain:

Semmes-Weinstein Monofilament Testing

No. : _____

Testing Positions	Date:		Date:	Date:
	R	L	R / L	R / L
1.Dorsal thumb proximal nail bed				
2.Dorsal middle finger proximal nail bed				
3.Ventral index finger tip				
4.Ventral little finger tip				



Appendix G
Visual Analog Pain Scale

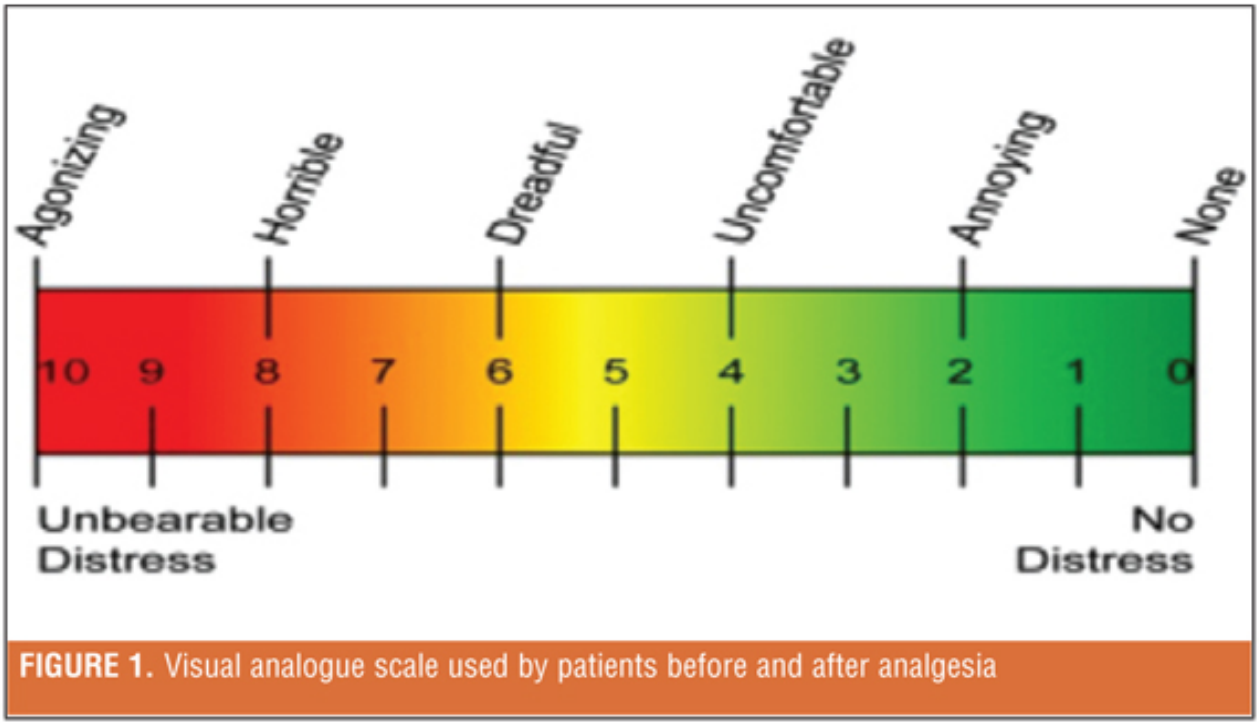


FIGURE 1. Visual analogue scale used by patients before and after analgesia

Appendix H

Occupational Therapy Department

Contrast Baths Home Program

Contrast baths are used to alter the sluggish circulation in your hand that allows the swelling to settle and become hard. The warm water opens the blood vessels while the cool water closes them, effectively causing an alternating pumping action. The pumping action is also aided by muscle contractions which occur if you alternately close your fingers and open them while in the baths. This active motion and pumping also aids in increasing range of motion in your hand.

You should be doing the contrast baths TWICE daily or as recommended by your therapist

MATERIALS REQUIRED — **Two containers (sink and a dishpan—don't use a bucket)**
Two soft sponges

PRECAUTION — **Always test the temperatures of the water using your other non-injured hand first. If unsure, ask someone in your family to test the water temperatures for you. Do not use your injured hand to test the temperatures as the sensation might be different in your injured hand**

PROCEDURE

1. Fill one container with cool water, using the regular cold tap water. The temperature of the cool water should not be so cold that you couldn't put your hand in it. (Recommended temperature is no lower than 66F)
2. Fill the other container with warm water. The temperature of the warm water should be like a nice comfortable bath water for you. (Recommended temperature is no higher than 96F)
3. Water level in both baths should be enough for you to submerge your whole hand up to 2 inches above your wrist. Place a soft sponge in each of the water baths
4. Begin with squeezing the sponge in the cool water six times SLOWLY. Open and close hand fully each time
5. Move to the warm water and squeeze the sponge six times SLOWLY. Open and close hand fully each time
6. Repeat this for 7-10 minutes
7. End your last set of squeezing in the cool water bath.

Appendix I

Occupational Therapy Department

Icing (Cryotherapy) Home Program

Icing (cryotherapy) is used to cool down the musculature of your hand and effectively closes the blood vessels in order to decrease the swelling in your hand.

You should be doing the icing TWICE daily or as recommended by your therapist

MATERIALS REQUIRED — **A commercially available gel pack no smaller than 5"x10" in order to cover your whole hand and 2 inches above the wrist. You should be able pick up a suitable ice gel pack at your local pharmacy and general stores**

PRECAUTION — **Do not apply the frozen ice gel pack directly over your skin. Always put a paper towel between the ice gel pack and your skin**

PROCEDURE

1. Remove the frozen ice gel pack from the freezer
2. Put a paper towel on top of your hand and wrist in between your skin and the frozen ice gel pack. Make sure you position the gel pack so that it can cover up your whole hand and 2 inches above the wrist
3. Sit quietly without moving your hand with the frozen ice gel pack in place for 7-10 minutes
4. After 7-10 minutes, remove the paper towel and the gel pack. Remember to return the gel pack to the freezer till next icing to be done

Appendix J
Home Program Log

No.: _____

Direction: Put a check mark each time after you have completed your home program. Thank you for your participation in our study

Your home program is _____

Date	1st	2nd	3rd	4th	Date	1st	2nd	3rd	4th

Please return this log sheet no later than: _____

Appendix K
POST-STUDY SURVEY

NO
:_____

Directions: Please circle the response you most agree with in each question. Thank you for your participation in our study

1. Your home program is

Contrast Bath	Icing

2. On the scale below, how easy it is for you to do the home program daily?

1 Very difficult	2 Somewhat Difficult	3 Neutral	4 Somewhat Easy	5 Very easy

3. On average, how often are you able to do the home program daily?

1	2	3	4	More than 4 a day

4. Overall, how *comfortable you are in doing your home program*?

1 Very uncomfortable	2 Somewhat uncomfortable	3 Neither comfortable or uncomfortable	4 Somewhat comfortable	5 Very comfortable

5. Do you find your home program to be effective in managing swelling in your wrist and hand?

1 Very ineffective	2 Somewhat ineffective	3 I don't know	4 Somewhat effective	5 Very effective

Additional comment(s): _____

_____