

Running Head: Above-Elbow Replantation

Life after Upper Extremity Replantation: An Examination of the Experiences of an  
Adolescent Male, his Family, and the Treating Certified Hand Therapist

April 30, 2010

This research, submitted by Karina M .O'Connor, has been approved and accepted in  
partial fulfillment of the requirements for the degree of Master of Science in  
Occupational Therapy from the University of Puget Sound.

---

Committee Chairperson: Lucretia Berg MSOTR/L

---

Reader #1: Martins Linauts Ph.D PT

---

Reader #2: Cathy Elvins OTR/L, CHT

---

Director, Occupational Therapy Program: George Tomlin Ph.D OTR

---

Dean of Graduate Studies: Sarah Moore MA, Ph,D

### Abstract

The purpose of this study was to gain an in-depth perspective on the experience of replantation of a traumatically amputated upper extremity and the subsequent rehabilitation process through the point of view of a 15 year old patient, his parents, his sister, and the treating Certified Hand Therapist (CHT). As an occupational therapist it is important to understand the family relationships, support networks, and the role of the patient in the family. The therapist is in a unique position to provide treatment and emotional support that the patient and family need after experiencing trauma. This case study appraisal using a qualitative design included an exploration of the hand therapy chart (including the surgical report) and audio recorded interviews with the patient, each parent separately, the patient's sister, and the CHT. A three interview structure for in-depth phenomenological interviewing was used with the patient. The results of the chart review explain the surgical procedures, the therapeutic interventions, and the process of healing. The results of the thematic analysis of the interviews revealed three salient themes: pain (i.e. emotional and physical), transformation (i.e. transformation of self and roles), and miracles (i.e. surviving, retention of the limb, and retention of the family). The findings suggest that coping after a traumatic accident is a family process and all of the family members will experience this process differently.

## Life after Upper Extremity Replantation: An Examination of the Experiences of an Adolescent Male, his Family, and the Treating Certified Hand Therapist

Survival rates after upper extremity replantation have greatly increased since the first successful replantation of an amputated limb in 1962 by Malt and McKahnn (as cited in Silverman, Willette-Green, & Petrilli, 1989). Unfortunately, the survival of a replanted limb is not a direct indicator of the restoration of function (Garner, 1988). The ultimate measure of success of a replanted limb is the patient's ability to use that limb for activities of daily living (Russell, O'Brien, Morrison, Pamamull, & Macleod, 1984). Successful functional use of the replanted limb is dependent on post-operative management. Cooperation among the patient, the family, the orthopedic surgeon, and the rehabilitation team is also crucial for a successful functional outcome (Chew & Tsai, 2001; Koul, Cyriac, Khaleel, & Vinodan, 2004). A Certified Hand Therapist has the skills to provide a comprehensive treatment for the client with an upper extremity replantation which includes addressing the physical, psychological, social, and work problems that may arise after replantation (Vennelle, 1988). A deeper understanding of the lived experiences of the replantation patient, the family, and the Certified Hand Therapist (CHT) may provide a unique perspective of this process.

### **Background**

The first microvascular surgery was reported in 1960 when Jacobsen and Suarez used an otological operating microscope to create an anastomosis in a 1 millimeter (mm) vessel (as cited in Chew & Tsai, 2001). The development of microsurgery, following technological advances in the production of microsurgical instruments and suture material, has now made possible the successful replantation of amputated limbs (Chew &

Tsai, 2001). Chew and Tsai reported that replantations of the distal forearm and wrist have the greatest potential for positive functional outcomes due to the intact extrinsic muscles and tendons of the hand. The complications seen at this level of injury are generally tendon healing and gliding rather than reinnervation of distal muscle and the return of sensation as seen in more proximal injuries (Chew & Tsai, 2001). One of the reasons that full functional recovery is unlikely to occur is that nerves only regenerate at a rate of 1-mm/ day (Chan & LaStayo, 2003). The amount of irreversible muscle damage after injury increases the longer the motor endplates are without innervation (Wei & Mardini, 2003). One recommended criterion for replantation is that the outcome of surgery should yield a level of function higher than that possible with the use of a prosthesis.

Major upper extremity amputation is defined as limb loss proximal to the level of the wrist. A type of major upper extremity amputation that accounts for only 3% of upper extremity cases is transhumeral amputation (Dagum, Slesarenko, & Winston, 2007). Despite the advances in microsurgical techniques, the prognosis for limb survival after a transhumeral replantation is only 50- 70%. Dagum et al. reported a case of a proximal transhumeral replantation in order to describe the long-term functional outcome of the replanted limb and to establish indications for replantation for future cases. In their case study a 26 year old woman sustained a left upper extremity amputation 10 centimeters (cm) below the gleno-humeral joint in a motor vehicle accident. The patient participated in an intense course of hand therapy consisting of passive and active range of motion exercises for shoulder and elbow, and passive range of motion for the wrist and hand. The patient was also taught anesthetic precaution and dominance transfer.

Function of this replanted upper extremity was assessed at a 10 year follow-up. All of the digits had diminished protective sensation. The patient was able to actively elevate, abduct and externally rotate at her shoulder joint and she could flex her elbow joint to 100 degrees and extend to 20 degrees. Her involved hand had enough active finger flexion to allow her to sustain grasp of small objects placed in the involved hand. Her grip strength was 10% of her noninvolved hand. Additional functional outcome assessments that were performed on this patient included the Short Form 36 (SF-36) (Ware & Sherbourne, 1992), the Disabilities of the Arm, Shoulder, and Hand (DASH) (Hudal, Amadio, & Bombardier, 1996), and Chen's Criteria (Chen, Meyer, Kleinert, & Beasley, 1981). The SF-36 scores for physical and mental outcomes were 47.4 and 52 (normative means being 52.5 and 48.3 respectively). These scores indicate that the patient's overall perceived health status was near normal despite experiencing a devastating injury. The DASH outcome score was 30 of a possible 100. For the DASH, a score of 0 represents no disability and a score of 100 represents extreme disability. Therefore, a score of 30 is a mild to moderate upper extremity disability. Chen's Criteria measured her functional recovery as excellent (Dagum et al., 2007).

**Indications for replantation.** When a surgeon is considering whether or not to perform a replantation surgery, the patient's age and general health, the length of time of ischemia, and the level, type, and extent of tissue damage need to be taken into consideration (Battiston, Tos, Clemente, & Pontini, 2007). People over the age of 50 usually have a greater number of complications and poor outcomes. Traditionally, up to 6 hours warm ischemia or 12 hours cold ischemia is the limit when considering replantation (Chew & Tsai, 2001). Sharp, guillotine-type amputations are associated with

better outcomes than crush or avulsion injuries (Chew & Tsai, 2001). A major upper extremity replantation is rarely performed on an adult; however, the indications for replantation are broader for children due to the absence of contraindications such as smoking, alcoholism, drug addiction, and systemic illnesses (Raimondi, Petrolati, & Delaria, 2000). In addition, replantations in children are often more successful than replantations in adults due to their better tissue healing capabilities.

In the pediatric population, growth is a factor that needs to be considered when predicting the outcome of the replanted limb. Growth discrepancies can be a problem in children who have had a major replantation (Raimondi, Petrolati, & Delaria, 2000). Not only will the child experience limb shortening during the replantation process when the bone ends are debrided, but the lack of sensation due to the nerve damage seems to stunt growth distal to the injury. Greater discrepancies in growth are expected when the amputation occurs more proximally to the trunk and when the child is very young (Raimondi et al., 2000).

**Surgical technique.** Once the surgeon decides that replantation is indicated, antibiotic therapy is started (Raimondi, Petrolati, & Delaria, 2000). The first step of the surgical process is wound debridement. As the wound is being cleaned, the essential structures are identified and tagged. Revascularization is performed as soon as possible. The re-establishment of blood circulation is performed with an arterial shunt until the arteries can be repaired. Before the venous shunt is put in place, the circulatory system is allowed to wash out the toxic metabolites left from the injury (Chew & Tsai, 2001). The bone is then shortened and stabilized. Bone shortening is necessary to ensure that the bony ends are clean and to allow sufficient slack for nerve and arterio-venous repairs to

be completed without too much tension on them. Protecting the epiphyseal plate during pediatric limb replantation is crucial (Raimondi et al., 2000). General muscle and tendon repairs are performed next. For tendon repairs it is necessary to make sure that the repair is strong enough to withstand immediate passive range of motion. Early mobilization is necessary to maintain tendon glide (Chew & Tsai, 2001). Fasciotomies are performed to prevent further damage that can be caused by postischemic edema. The nerve repairs are the final step before skin closure. Depending on the injury, a skin graft or free flaps may be required (Raimondi et al., 2000).

Complications of replantation include bone nonunion, bone infection, skin and muscle necrosis, bleeding, and brachial plexus palsy (Raimondi, Petrolati, & Delaria, 2000). Common secondary procedures after replantation include tendon transfers, skin grafts, tenolysis-arthrolysis, nerve grafts, treatment for nonunion, plexus repair, and free flaps. Multiple surgeries are almost always needed in order to enhance the function of the replanted limb (Chew & Tsai, 2001).

**Outcomes.** According to the Subcommittee on Replantation by the International Federation of Societies for Surgery of the Hand, the accepted criteria for functional outcome measures are Chen's Criteria for forearm and arm replantations (as cited in Chew & Tsai, 2001). Dagum, Slesarenko, and Winston (2007) used the Short Form 36 (SF-36) and the Disabilities of the Arm, Shoulder, and Hand (DASH) assessments of function in addition to the Chen's Criteria for a more complete picture of the function of the replanted upper extremity. It is generally accepted that the more proximal the amputation is to the trunk, the less likely the final outcome is expected to be typical function. Battiston, Tos, Clemente, and Pontini (2007) published a case series on 38

major segment replantations that were performed in their department from 1992-2002. The average follow up for these patients was 4.2 years. Chen's Criteria, X-rays, and the length of time it took for social reintegration were used as outcome measures. Based on Chen's Criteria, 61% of the replanted limbs had good results. The more distal replantations had higher scores on Chen's Criteria suggesting that they had better functional recovery. None of the patients returned to their previous occupation. The researchers made note that the eight patients with the lowest scores according to Chen's Criteria preferred the poorly functioning replanted limb to amputation. This outcome may be due to the fact that currently, there is no prosthesis that can match the hand in its ability for complex function (Chew & Tsai, 2001). For Dagum et al., the first goal was the survival of the replanted limb and the second goal was to achieve an extremity that can help carry, hold, and oppose the contralateral extremity.

**Post surgical intervention.** Successful functional use of the replanted limb is dependent on post-operative management. Common interventions following replantation include splinting, edema control, wound care, scar management, early mobilization, sensory re-education, desensitization, and increasing active motion and strength to match the stages of healing (Scheker & Hodges, 2001; Chan & LaStayo, 2003). Currently, there is no standard protocol for rehabilitation following replantation surgeries (Papanastasiou, 2002). Every amputation is going to be different and the application of the rehabilitation protocol after replantation must match the healing process of the limb (Chan & LaStayo, 2003). The limb needs to be constantly reevaluated for changes (e.g. increased or decreased edema requires splint adjustments and the skin integrity needs to be monitored to prevent tissue breakdown) (Scheker & Hodges, 2001). Most importantly, the hand

therapist needs to know how the structures were repaired in order to protect them during rehabilitation (Chan & LaStayo, 2003).

Once the limb is deemed viable, preventing deformities and reestablishing function are the goals for rehabilitation (Scheker & Hodges, 2001). The therapist must provide controlled stress to the various structures in order to enhance tendon gliding, decrease joint stiffness, and decrease edema (Silverman, Willette-Greene, & Petrilli, 1989; Papanastasiou, 2002; Chan & LaStayo, 2003). There is no agreed upon timeline for these interventions to occur; however, early mobilization beginning in the first week is considered essential for a positive outcome (Papanastasiou, 2002; Chan & LaStayo, 2003).

The patient must be prepared for a long, intense rehabilitation process and multiple surgeries. The patient's active participation and motivation during the rehabilitation process is crucial for successful recovery (Vennelle, 1988). Qualitative studies on limb replantation can provide important insights for patients experiencing upper extremity replantation, the hand therapists, and other professionals working with these patients. According to Kumar, Grewal, Chung, and Bradley (2009) the current military operations, including Operation Iraqi Freedom and Operation Enduring Freedom in Afghanistan, have called for attention to the principles regarding management and reconstruction of the upper extremity after war injuries. The likely increase in patients with replantations due to war injuries makes it important to consider the emotional as well as the physical aspects of this trauma when treating these patients.

**Purpose.** The purpose of this study was to gain an in-depth perspective on the experience of replantation and the subsequent rehabilitation process through the point of

view of a 15 year old patient, his parents, his sister, and the treating Certified Hand Therapist (CHT). Despite extensive review of the literature, the investigator was not able to locate any published qualitative research on the experiences of a patient and family after amputation and subsequent replantation of a limb. An exploration of this experience would provide important insights for hand therapists and other professionals working with patients after replantation. Thus, a case study appraisal was selected as being the most appropriate method.

## **Method**

### **Research design**

A case study appraisal using a qualitative design was employed to gain insight into the lived experience from the perspectives of the patient, his parents, his sister, and the treating CHT 18 months after replantation. The investigator was the clinic aide at the hand therapy clinic when the patient began hand therapy (i.e. fifteen days post replantation surgery). The CHT recommended that this patient would make an interesting case study and the patient and his family agreed that their experience could be of benefit to others. This study included an exploration of the patient's hand therapy chart, the surgical report, and audio recorded interviews with the patient, each parent separately, his sister, and the treating hand therapist. Three interviews were conducted with the patient and one interview with each of the parents, the sister, and the CHT. All of the interviews were kept under 90 minutes.

### **Participants**

A convenience sample of five participants was recruited for this research: the patient, the parents of the patient, the patient's sister, and the CHT. All of the names

have been changed in order to maintain the confidentiality of the participants. At the time of the data collection (i.e. 18 months status post replantation surgery), the patient participant, Tom, was a 15 year old white European American male. Both the parents (Mom and Dad) were in their fifties and reported an ethnicity of white European Americans. The patient's sister, Emily, was an 18 year old white European American female. The CHT who worked with the patient was a white European American female in her fifties. All of the participants were from the Pacific Northwest and reported stable mental and physical state of health at the time of the study.

### **Instrumentation**

A semi-structured interview was conducted with each of the participants. One interview was performed with each of the parents, the patient's sister, and with the hand therapist in order to establish the context for the patient's experience from the perspective of those who observed the patient's journey. Seidman's (2006) three interview structure for in-depth phenomenological interviewing was used with the patient. The aim of the first interview was to establish the context of the patient's experience through knowledge of the patient's life history. It included a review of the patient's life history up to the point of the accident. The aim of the second interview was to allow the patient to reflect on the experience of the trauma and rehabilitation within the context of his life in order to establish the patient's contemporary experience. The purpose of the third interview was to allow the patient to reflect on the meaning of the overall experience to him (Seidman, 2006). The participants were assured that they could stop or redirect the interview questions at anytime without repercussion if the questions caused psychological discomfort.

**Procedure**

After the project received approval from the Institutional Review Board at the University of Puget Sound, consent forms were delivered to the participants. As soon as the signed informed consent forms were returned, the researcher reviewed the hand therapy chart and the surgical reports at the physical therapy clinic the patient attended. A thorough chart review of the interventions used and the documented outcome of the limb were conducted and documented for use during the interviews and for the final analysis. The data from the chart were then summarized and cross-checked with the hand therapist to ensure that it was an accurate reflection of the case. The interview questions were piloted with an Occupational Therapy professor at the University of Puget Sound in order to ensure the open-ended questions designed to guide the interview would not cause emotional distress and to practice what to do in case the participants expressed emotional distress. The participants each scheduled for private independent interview sessions. The CHT and each of the patient's parents were interviewed followed by the series of three patient interviews. For the patient's interview there was a three day lag period between each interview to permit time for reflection on the information, but not so long that there was a disconnection between the interviews. The interviews were kept under 90 minutes each, long enough for an in-depth interview, but not so long as to cause diminishing return in the subsequent interviews. During the interview with the patient's dad it became apparent that the patient's sister played a crucial role in the family dynamics after the accident. The University of Puget Sound's IRB gave permission to interview the sister. This interview was conducted after all of the others took place. All of the interviews were audio recorded and later transcribed verbatim by a professional

transcriptionist. Finally, the researcher analyzed the transcribed interviews in order to identify the themes that were most significant for this case (Seidman, 2006).

### **Data Analysis**

The transcribed interviews were analyzed in order to reduce the material into the most salient themes. First, the passages that were considered to be meaningful were marked. Further analysis of these passages was completed in order to place the excerpts into categories (Seidman, 2006). Words or phrases that described the categories were used to code the data. Within each category, the investigator looked for patterns or connections among the excerpts in order to reveal the salient themes. Next the themes were compared across the participants. The data retrieved from the chart review was compared with the prominent themes uncovered from the analysis of the interviews in order to determine to what extent the physical data presented in the chart was reflected in the patient's experience. Finally, the strategy of member checking was employed as the participants were given an opportunity to review the themes and voice their opinion as to whether the themes were an accurate representation of their experience (Hammell, Carpenter, & Dyck, 2000).

### **Results**

Tom's eighth grade year was filled with school, sports, and friends. His favorite classes were science and physical education. Tom reports that he received A's in all of his classes. His career aspiration was to be a professional athlete. During the winter, Tom described "school as being kind of centered around snowboarding." He had open class times during the day so he could snowboard and then do homework in the evening. That year he placed first at the national snowboarding competition for his age group. In the

spring he played golf every day with the weekends spent playing golf with his dad. That year Tom placed on the podium at a local golf tournament. During his eighth grade year, he felt like his golfing skills had really begun to develop and he started leaning towards becoming a professional golfer over being a professional snowboarder.

### **The Accident**

Tom was 14 years old when he was on a surfing and camping trip with his family. It was the last day of their vacation, so Tom, his sister, and their two friends went surfing one more time while Tom's parents packed up the camping equipment. While they were surfing, a dory boat trying to land on the shore approached a group of surfers. Tom, one of the surfers, couldn't hear the boat coming over the sound of the surf. He reports "I came over a wave and saw a boat coming at me and there was no way I was going to be able to paddle out of the way, so I decided to swim down ... and not take the boat right on top of me." Unfortunately, the boat was traveling fast and Tom could not dive deep enough off of his board. He was hit by the boat's engine propeller, causing his left arm to be traumatically amputated and his scalp lacerated. Tom remembers "getting sucked up and then feeling an excruciating pain." A fellow surfer saw what happened and helped Tom to the shore, while another surfer found the arm floating in the ocean. During this time Tom never lost consciousness.

Emily and her friend were walking down the beach when they heard commotion and saw a group of surfers helping someone out of the water. Emily recognized the blue surfboard and knew that her brother was injured. Emily's friend reached Tom first and blocked her view of Tom while telling her that she needed to go get her parents. Emily immediately thought that Tom had been attacked by a shark and would not survive.

While still in her wetsuit, Emily ran approximately a half mile to the campground to get her parents. By the time Tom's parents and Emily returned to the beach, Tom had been loaded into a Sheriff's truck. Emily's friend drove Mom and Emily to the local hospital while Dad rode in the ambulance with Tom to the hospital. After he was stabilized, Tom was air lifted with his mom to a major trauma center.

### **Surgical Report**

On preoperative imaging it was noted that Tom had a left hemothorax; therefore a chest tube was inserted near the left lung in the operating room. His scalp laceration received stitches. The amputated portion had six liters of saline circulated through the arm and was soaked in Betadine prior to the surgical procedures. Once the left arm was prepped and draped, the brachial artery and vein were shunted in order to allow recirculation of the arm. The total ischemic time was approximately 2.5 hours from the time of amputation to time that blood flow was reestablished in the arm. Blood was allowed to circulate through the arm for 20 minutes before the surgeon began the replantation procedure in order to ensure the arm had sufficient capability for circulation. A thorough debridement of all affected skin, bone, ligament, and tendon structures was performed. There was a large amount of skin loss anteriorly and laterally. The triceps, biceps, brachialis, brachioradialis, and wrist extensors had been damaged.

First the supracondylar humerus, which was in two pieces, was stabilized to the humeral shaft. There was a comminuted segment that was removed which shortened the humerus by 3 centimeters. The instability in his elbow was reduced. The brachial artery was reanastomosed to the major brachial artery and the brachial vein was reanastomosed to the major brachial vein. The ulnar, median, and radial nerves were reanastomosed by

removing the severely contused portions which were then sewn together with good fascicular match-up. The triceps and the biceps were injured through the tendinous portion; however, a good portion of each muscle was preserved. Both were repaired and the biceps was brought down into the antecubital fossa in order to cover the neurovascular bundles underneath. The radial wrist extensors were sewn together. Skin flaps were created medially, anteriorly, posteriorly, and laterally to cover the neurovascular structures. The proximal compartments of his forearm were released as a preventative measure in case of swelling. Allograft skin was used to cover the exposed muscle. Tom's arm was placed into a posterior splint and was observed to have good capillary refill in his fingers. A secondary surgery was performed a few days later in order to place a split-thickness skin graft harvested from his thigh over the remaining portion of exposed muscle.

### **Chart Review**

Hand therapy began fifteen days post replantation surgery. Tom arrived for therapy with his family. He was wearing a long elbow splint and his arm was in a sling. Treatment began with wound care, active range of motion (AROM) of his left shoulder, passive range of motion (PROM) of his left wrist, fingers and thumb, and edema mobilization of the left hand. The physician's orders stated for therapy to continue three times a week. On the second day of therapy the CHT changed the wound dressing protocol from Xeroform to wet to dry dressings over the areas of the wound that were soupy in order to prevent maceration. Wound care included debridement of eschar and exudates. Passive range of motion at elbow and forearm was begun. The CHT passively ranged the involved elbow to extent that Tom could tolerate with the goal of increasing to

full flexion as soon as possible. He could only tolerate elbow extension to 90°. Tom was able to perform shoulder flexion and abduction independently, but he required assistance for shoulder external rotation. As the wound area in the cubital fossa healed, the amount of passive elbow extension was increased.

At 24 days post replantation surgery, pseudomonas was found in the wound. Silvadene was added to the wound dressing protocol. Granulation tissue started to form in the wound bed. The increased passive elbow extension caused a crevice to open in the fragile skin of his cubital fossa. Wound powder was added to the wound care protocol for the 9 mm long, 9 mm deep, and 5 mm wide (when arm was in extension) crevice. Functional movement of elbow flexion with supination and elbow extension with pronation was begun.

At 29 day post replantation surgery, the wound dressing protocol was changed to Adaptic over the areas with granulation tissue with continuation of wet to dry dressing with Silvadene over areas of the wound with no granulation tissue. At this point, 70% of the wound bed was healed with epithelization. At 32 days post replantation surgery, scar tissue in the elbow started to form which caused elbow and forearm movement to be more restricted. As areas of tissue healed, lotion was added to the wound care in order to keep the fragile new skin moist. At 35 days post replantation surgery, Tom was recommended to decrease the use of the elbow gutter splint during the day in order to have gravity assist to increase elbow extension. The new skin tended to blister easily with friction; therefore, a compression sleeve for his elbow was issued in order to reduce friction over the fragile skin and to prevent hypertrophic scarring

At 65 days post replantation surgery, Tom had his first return of motion. He was

able to move his index finger slightly at the proximal interphalangeal (PIP) and metacarpal phalangeal (MCP) joints and slight movement was observed in his middle finger. At 79 days post replantation surgery, Tom reported less pain. Upon specific muscle testing, patient was able to isolate his index finger flexor digitorum superficialis (FDS) and compositely activate his FDS of all other fingers. He demonstrated active wrist flexion through the use of his finger flexors. Active pronation and supination were observed with his biceps acting as a secondary supinator. At 105 days post replantation surgery, Tinel signs were reported down to his wrist from the median nerve and 1/3 of the way down his forearm from the radial nerve. At 114 days post replantation surgery, composite flexion was observed in ring and little finger as FDS function improved. At 128 days post replantation surgery, Tom went into surgery in order to have the deep hardware removed and replaced with two smaller plates on the humerus along with a bone graft from his iliac crest in order to correct the non-union of the humerus. A Z-plasty was also performed at the anterior elbow in order to increase function by decreasing the skin tension caused by the scar tissue.

At 141 days post replantation surgery, Russian stimulation to the muscles of the hand and wrist was attempted with the goal of stimulating motion in the hand. There was no response. A point stimulator was also attempted with high voltage and direct current, with no response. At 158 days post replantation surgery, scar massage was attempted with resulting blistering over the posterior surface of the wound. The CHT continued to perform scar massage over the anterior aspect of the wound as the blisters healed on the posterior aspect of the arm. At 163 days post replantation surgery, the wound was completely healed. At 162 days post replantation surgery, Tom returned to snowboarding

for the first time since the accident.

In summary, interventions used included wound care, edema management, soft tissue mobilization, stretching, and increasing range of motion at the elbow, forearm, and hand. As muscles became reinnervated, strengthening exercises were added. An elbow gutter splint was used at first for protection of the wound and the healing fractures and later used as a night splint to progressively increase elbow extension. A resting hand splint for night wear was used to prevent flexion contractures at PIP joints and the thumb. A wrist cock-up splint was fabricated for use during the day in order to position the hand for maximum function. A compression sleeve for his elbow was used to reduce friction over the fragile skin and to prevent hypertrophic scarring. An edema glove and tubigrip stocking was used in order to decrease the edema in the patient's left hand and arm. A lacing wrist brace was issued once Tom had gross grasp in his hand so that he could play golf.

### **Thematic Analysis of Participant Interviews**

There were three salient themes that became apparent after the thematic analysis of the interviews (see Figure 1 for an example of the thematic analysis of the Tom's third interview). The first major theme was "pain" which includes both emotional as well as physical pain. As Tom and his family learned to cope with their pain in the aftermath of the accident, they all went through a transformation of self, leading to the second theme. The second major theme was "transformation" which includes transformation of self and transformation of roles. As Tom and his family went through their own transformations their outlook changed in a positive direction. This led to the final major theme of "miracles." The theme of miracles included surviving the accident, replantation of the

arm, return of function in the arm, retention of the family unit after a major trauma, and retention of hope throughout the rehabilitation process.

### **Theme of Pain**

**Tom's pain.** Tom's physical pain during the accident was described as being excruciating. At the time Tom didn't know that he had lost his arm: he just knew that he couldn't feel his fingers. After the replantation surgery, Tom described the pain in his left arm as "... hurting really badly. It was a constant tingle, like a stinging, vibrating, pulsating, uncomfortable feel that never went away and nothing helped." Tom also had other injuries from the accident that were painful, including four broken ribs, a punctured lung, fractured vertebrae, and a scalp laceration. Since Tom spent the first 12 days after the accident in a hospital bed, he developed bed sores. Tom also had residual pain from the surgical procedures. For example, Tom was unable to get out of bed unassisted due to the skin graft donation sites being incredibly painful. Just moving from sit to stand would cause uncontrollable pain that would "just sting and stay with my body for a while." Tom also had to deal with the pain that resulted from hand therapy intervention such as manual therapy to increase the range of motion in his elbow and to maintain the range of motion in his hand. Any pressure in his hand would cause shooting nerve pain through his arm. On top of the physical pain caused by the physical trauma sustained in the accident, Tom had to come to terms with the emotional pain in the aftermath of the accident. The emotional pain included Tom losing his lifelong dream of becoming a professional athlete, contending with worry about contracting an infection and losing the arm again, and the acceptance of having to rely on others to perform typical daily activities that he used to be independent with.

**Mom's pain.** Tom's mom reported being unable to get out of the car and go to her son when the family arrived at the beach.

I guess what haunts me is once we came upon the Sheriff's truck I never got out of the car and I never went to him. I just froze. And I think: what kind of mom am I? But I knew [his dad] was with him and I was so afraid of what I was going to see. I just remember sitting in the car praying that he wasn't going to die.

His mom reported that "you never want to see your kids in pain. And he worked so hard and was so strong that, like I said, he gave us all strength."

**Dad's pain.** Tom told his dad, while riding in the back of the sheriff's truck, that he could not feel his fingers. Dad replied "you just have a bad cut!" This statement helped minimize the injury to a level that Tom and his dad could deal with at the time. Dad and Emily returned to the campground once Tom and his mom were on their way to the hospital via helicopter. Dad and Emily had to pack up the camping equipment and their dog before joining Tom and his mom where he was being treated. Since it was a holiday weekend, it took five and half hours to drive to the hospital. There was no cell service at the campground or for most of the drive. Dad describes the lack of ability to communicate and receive news of his son's status as being "by far the worst thing I have ever experienced in my life."

After the surgery and during the recovery process, Tom's dad was concerned with how post-traumatic stress was affecting everyone involved. He recognized that "you can't forget about the other siblings and there have been times when it affects my relationship with my wife." In regards to his own mental health, Tom's dad explains that

It affects me and it still affects me a lot. I can swing into depression and I can swing into anger because of the way the accident happened. It was something careless in my opinion. I wish it would have been me and not him.

Mom reported that, especially for Tom's dad, it has been hard to accept that they have no communication with the person who was driving the boat and to know that no one is being held accountable or responsible.

Tom's dad had to adjust to losing his son as a sports companion. Tom and his dad used to participate in activities together such as playing golf every weekend, surfing, and snowboarding. He also had to cope with losing the role as Tom's sports coach and traveling companion for all of Tom's sports competitions. His dad also reported that "the hardest thing is to look at how it's affected his lifelong dream of being a professional athlete." Throughout the entire recovery process Tom's dad was very proactive in researching treatment ideas that could help in his son's recovery. Even now he reports wondering if there is another therapy or treatment that could help Tom have more return of function.

**Sister's pain.** Emily had the burden of having to tell her parents that Tom had been injured. At the time, she had thought that he was dying and had been attacked by a shark. Emily had to run about a half mile in a wetsuit from the beach in order to reach her parents at the campground.

I was the one who had to carry the burden to tell my parents something so horrible... That was just as awful as having to sit there with Tom at the beach. Everyone has a different experience and everyone has different feelings towards it.

Both of Tom's parents and his sister received services from a psychologist to help manage their post-traumatic stress. Emily said that it was helpful to have an outsider be a listener during this time of adjustment and acceptance of change. She knew that her parents were occupied with helping Tom through his recovery process and dealing with their own experiences of post-traumatic stress at the time

and were not always available to talk. Having to adjust to the fact that all the attention was on Tom was something that Emily struggled with. The accident and the publicity it received meant that Emily lost some of her own identity as she became known in the community as Tom's sister. "For example, at the grocery store people will come up to me and before they even say 'Hi' to me they ask 'How is your brother?' "

In the aftermath of the accident, the family routine changed as Tom's physical and rehabilitative needs became priority. Emily had a hard time adjusting to changes in family routine such as changes in their daily family dinner. Often Tom was physically unable to make it to the dinner table or dinners were served later because of Tom's hand therapy schedule. The family also had to miss some of Emily's dance performances due to Tom's hand therapy appointments. She also had to rely on friends to take her home from school instead of her parents picking her up. Emily states that she knows it is important to be as understanding as possible, but that it is hard to have the attention completely focused on the other sibling. The entire family had to experience change in order to accept and cope with the physical and emotional pain caused by the accident.

### **Theme of Transformation**

**Tom's transformation of self.** Tom learned to cope with the pain by taking his focus off the physical pain and by focusing on the future outcome of his arm.

Even though it hurt for the hour that I was there [hand therapy], I knew that in the long run it was helping me for the rest of my life. I thought

about other stuff when it was happening and I really didn't concentrate on the pain. I just thought about the future and what a great story it would make if I came back and could do most of the things I used to do.

Dad reported that Tom never complained or whined about the pain. Tom credits his participation in hand therapy as helping him cope with the pain because it made him feel like he was doing what he needed to do in order to get better. Tom continues to be a self-motivator and do whatever he can to gain as much function in his arm because he does not want to have any regrets when he is older. "I try to stay as positive as I can and look to the future." When asked for recommendations on how to cope with the pain and the rehabilitation process, Tom said for the patient to ask him/ herself:

1. What do you want for your future? It depends on how hard you work and the more you keep a good attitude... the better it is going to be in the long run.
2. Keep your head up and don't get down and don't get angry because that is not going to help you.
3. If you give up nothing good is going to come out of it, but if you try hard you'll get something good no matter what
4. You are going to face things in your life that are tough.... Are you going to work through it or give in to it?

Since the accident and his experience of going through rehabilitation, Tom's new career aspirations include going into physical therapy or sports medicine. He would like to help people and he feels like he could relate to people going through the recovery process after experiencing an injury.

**Dad's transformation of self.** Tom's dad believes that this study is

just the tip of the iceberg as far as the positive things that are going to come out of this horrible ordeal.... You just have to tell yourself that this happened for a reason. Tom will be an inspiration for others.

Dad's ability to let go of his anger as a parent was a significant step in his recovery process. He is now able to recognize the positive things that have occurred due to the

accident, such as the family having a greater appreciation for each other and the time they get to spend together.

**Mom's transformation of self.** Like Dad, Mom reports being more appreciative of the small things. She has tried to stay positive and realize “what is still ahead of us” and to come to terms with the fact that “the outcome may not be all that we wish for, but it could've been so much worse.”

**Sister's transformation of self.** Emily is a senior in high school this year and she has been applying to colleges far from home in order to have a fresh start where no one has heard of the accident. In her current participation in sports and other activities, she reports that Tom has inspired her to “actually do something to my full potential instead of just half way.” This was after Tom rejoined the golf team and played in a tournament one handed. He also inspired Emily to enter a state competition that involved creating a bill in order to better society. She wrote a bill that would help prevent a similar accident from happening to someone else. The bill Emily wrote won the competition and is currently being pushed through the legislative system in the state where the family resides. Emily believes that the accident happened for a reason and she is willing to let it change her for the better.

**Tom's transformation of roles.** After the accident, Tom took the role of a pillar of support for the rest of the family. Mom reported that Tom told his dad, when his dad was struggling with anger, to “get over it, Dad, I'm over it. The boat driver is not part of our life. We are lucky, and think of all those blessings that have come our way because of this accident.” Emily reported that “Tom finally realized that everyone else was so worried about him and he started reassuring all of us... 'I'm fine, it's going to be okay, and

it doesn't hurt too bad...' "

Tom participated in student council at his high school as the Freshman Representative. This was something that he normally would not have had time for because of his participation in sports. The limitations caused by the injury gave him an opportunity to try new activities and meet new people. Tom took advantage of that opportunity.

**Dad's transformation of roles.** Tom's dad went from being coach and best friend to being caregiver to his son. Now Tom is pulling away and searching for his independence. Mom explains that "before the accident they did everything together." Adjusting to his new role, as a dad, has been a huge adjustment for Tom's dad. With his concern for the family dynamics after the accident, Dad tried to become even more involved in Emily's life.

**Mom's transformation of roles.** Similar to Tom's dad, his mom had to return to the role of caregiver when Tom was first injured. She admits that "I still tend to fuss over him a bit and he'll once in a while ask me to tie his shoes.... He's been pretty self-sufficient so I've had to back off on what I do for him." Adjusting to the transition from her son being independent to being dependent on her for most of his needs and then adjusting again now that he is able to be self sufficient has been difficult. She reports having to let go of her nurturing side now that he is starting to pull away and reassert his independence.

**Sister's transformation of roles.** After Tom was injured, Emily also took on the role of caregiver. She recalls making extra trips up the stairs for him when he couldn't, helping Tom open drinks, and tying his shoes. She also helped him in the transition to

high school by meeting all his teachers, helping him navigate the new school, and carrying his books to class.

Now that Tom is able to do these things on his own, Emily has taken the role of a coach in order to push him to do things that he can do with his left arm even though it may be hard and take time. She also acts as a distracter to help him get through his exercises now that it is becoming harder for him to remain motivated.

### **Theme of Experiencing a Miracle**

**Surviving the accident.** While describing the accident, Tom's dad explained that the medical team told him that if Tom had spent another minute or two in the water, he would have died from blood loss. Not only did the family come close to losing their son and brother, but there was a period of time after the accident that the entire family believed that Tom was dead.

Emily had immediately thought that he had been bitten by a shark. Being a surfer all my life, I [Tom's dad] immediately thought he wouldn't be alive. The time it took to get from the campground to the beach area seemed like an eternity. The first vision I had of him was he was alive, he was conscious, he wasn't in that much shock, but yet there was nothing left. There was just a bloody stump above his elbow where the arm had been severed off by the boat's engine. I pretty much accepted the fact that he had lost his arm for good....

Tom's mom reflects over the past year and a half and explains that "we came so close to losing him that of course all these small steps through his rehabilitation have just been blessings and the fact that we have him, number one, and the fact that he even has his arm...." Dad comments that "everything that occurred was a series of blessed events that kept Tom alive."

**Replantation of the arm.** It was a miracle that another surfer was able to find Tom's arm floating in the ocean. Tom was lucky that he was able to receive swift medical care

from a physician and the local Sheriff on the beach. It was fortunate that the orthopedic surgeon on call that weekend was a specialist in hand surgery and microsurgery. Tom was fortunate to be considered a prime candidate for replantation surgery because of his young age, health, and athleticism.

**Return of function in the arm.** When asked what it was like to see the replanted arm move for the first time, Tom explained “I was constantly focusing on my hand just trying to move it and doing as much as I could to help it get better.” “Even though it moved barely enough to see it, it was probably one of the happiest moments in my life.”

Currently, Tom is wearing a prefabricated lacing wrist brace for most of his daily activities as he is still using his digital extensors to overcome gravity in order to bring his wrist past neutral and into extension. His left hand is slightly smaller than his right hand. Tom does not appear to favor his hand while sitting or moving around. He is able to oppose his thumb to his index and middle finger. Tom has isolated thumb flexion only for a short portion of the range until all the digital flexors come together for gross grasp. At this time, Tom’s ability to supinate is limited to activation of his biceps (a secondary supinator) due to the fact that his supinator is not intact. His first dorsal interosseous is now firing more consistently and his abductor digiti minimi is beginning to contract. Tom has no thumb or digital abduction. Tom’s decreased elbow extension, supination, pronation, and MCP flexion in his digits are limiting factors to upper extremity function (see Table 1 and Table 2). His grip and pinch strength in his left hand is notably less than his right hand (see Table 3).

*Sensation.* Tom reports normal sensation in the palm, the index finger proximal to the DIP joint, and the small finger with slight tingling at the DIP. The thumb feels normal

up to the IP joint where it becomes hypersensitive. The results of the Semmes Weinstein demonstrate that Tom has diminished light touch as his sensation begins at the 3.61 monofilament. Also, for most of the trials he was unable to localize to the correct digit with the exception of the small finger and one time on the thumb. Tom is still sensitive to deep pressure at the thenar eminence, but the hypothenar eminence is not sensitive to deep pressure.

*Functional Activities.* Tom reports being able to hold a juice can and the strap of a water bottle. He uses the left arm as a helper hand (with wrist brace on) to lift objects. Tom also uses the arm to pick up items such as his jacket using gross grasp. He can individualize his digits to get them into a glove. Currently, Tom is attempting to type using both hands. In his left hand he uses mostly his index finger and thumb during typing.

**Retention of the family through the trauma.** This family experienced a traumatic life event and instead of being broken apart by the stress and emotional pain, the family worked together and provided support for each other. The process of retaining the family unit was assisted by many factors. First of all, the role of the CHT in providing hope and a tangible avenue for recovery was an important one for helping the family members maintain a positive outlook.

The CHT working with Tom took the role of instilling hope in the patient and family. He stated that “the best thing about therapy was having the CHT and the rest of the staff there to congratulate me when something new was happening with my arm.” Tom and the family weren’t always able to perceive the changes since they were looking at his arm everyday. The CHT had the hand therapy aide take pictures of his left arm

everyday starting from the first day. This made it easy to look back and see progress from one treatment session to the next.

The CHT had the role as the available professional of imparting information about what to expect and what to look for in the recovery of the arm. The CHT reported that she felt her role was to give the Tom and his family realistic expectations about the probable outcome of the functioning of the arm. Tom and his family reported that the CHT was good about collaborating with them. Especially with Tom and his dad, she took their ideas into consideration and would talk through the treatment interventions with them.

Secondly, the community came together to provide unexpected support. This support demonstrated that people are still good at a time when the family could have lost their faith in humankind. People who were strangers to the family donated their time, money, resources, and prayers. Tom still has baskets of unopened mail from people in the community and surrounding areas with get well wishes. Tom's dad explained that "if it wasn't for all of the friends and the positive outpourings of support that has just been tremendous to us, we would have never made it through this." Mom found it to be incredible to see the "good nature in people despite the economy and knowing everyone has problems and struggles and yet they still found time to write a letter or prepare a meal." The family also commented how important it was for them to feel that the medical team truly cared for Tom and how he was recovering.

**Retention of hope.** Every participant interviewed firmly believes that Tom has not reached his full recovery yet. Tom's mom, dad, sister, and CHT feel strongly that "with Tom's drive and determination he can still become a professional athlete." His

mom trusts that “Tom will figure out a way to play professional golf if that is what he wants to do. He’s very driven in that sense.”

### **Discussion**

Tom was an independent adolescent who was enjoying his summer before entering high school when his left arm was traumatically amputated. After the accident and the replantation surgery, he was dependent on his family to help him with all of his self care needs. When the family got home from the hospital, it was really difficult to get Tom comfortable because of all of his injuries and in response, his family struggled with watching him in pain. Tom’s mom, dad, and sister reported having a fear of causing unnecessary pain when helping him with his exercises, putting on his devices such as the waterproof sleeve so he could take a shower, or by simply bumping his arm when in a hurry. Each of the family members also reported emotional pain in regards to their role in the accident. The entire family expressed a desire that boating accidents like the one Tom experienced be prevented in the future. Tom’s strength in coping with the accident and the pain helped his family manage their own emotional pain. As he regained his ability to take care of himself, Tom’s family went through yet another transition as he started to regain his independence from his parents.

Tom believes the accident has “made us stronger as a family,” specifically that it made his parents and sister stronger as individuals because they had to see how much he was hurting. Tom’s dad agrees and explains that “as a family unit we really had to work together as a team, especially my wife and I, in balancing the attention between two children. This has been the biggest challenge and we’re making it.” Emily describes it as the family reaching a “new normal.”

**Coping and resilience after trauma.** Research suggests that traumatic experiences often increase negative family characteristics such as poor parenting, marital conflicts, and poor communication between family members (Punamaki, Qouta, Sarraj, & Montgomery, 2006). On the other hand, there have been reports of clinical observations of traumatic experiences resulting in feelings of cohesion within the family and a greater appreciation for family life. Some trauma victims report positive changes in themselves such as greater spirituality and appreciation for life (Punamaki et al., 2006). This resilience is attributed to psychological insight, supportive relationships, flexible coping skills, creativity, easy temperament, and positive family characteristics. Punamaki et al. examined symmetries and asymmetries within family members' psychological distress and resources after being exposed to traumatic events. The results of their study included the phenomenon of complementary dynamics between family members. This family dynamic suggests that there is often a balance created between family members' expressions of distress and strengths. For example, when parents expressed distress, their children tended to not express their own pain, and vice versa. This phenomenon was similar to the observations reported by Jaffa in 1993 (as cited in Punamaki et al., 2006).

Similar to the observations reported in the Punamaki, Qouta, Sarraj, & Montgomery (2006) study, strength and resilience after trauma were described in the interviews with Tom and his family. Each family member reported feelings of greater cohesion within the family unit and a greater appreciation for family life. Also, Tom took on a role of great strength and resilience when he realized his family was suffering. During the interviews, Tom demonstrated psychological insight and flexible coping when talking about the accident and how he chose to deal with the aftermath of the injury. Tom

and his family were surrounded by supportive relationships: between family members, with the surgeon, with the CHT, with friends, and with the community. Tom's family and the CHT reported that Tom had an easy going temperament and attitude that was surprising when considering his age. Tom was creative in finding ways to adapt activities and occupations to match his abilities.

### **Implications for Occupational Therapy**

After a traumatic accident, such as the one that Tom experienced, the patient and the family go through a grieving process. The family will grieve for the child's lost function and may have to deal with feelings of guilt such as self-blame or survivor's guilt. Buschman (1988) describes the mourning process after receiving a chronic life changing diagnosis as being a sequence of reactions which includes shock, denial, sadness, anger, and anxiety that later resolves into adaptation and reorganization. She also states that this mourning differs from that of mourning following the death of a child because the life of a child with a chronic diagnosis continues and the demand for parental care may increase.

As healthcare professionals, it is important to recognize the grieving process and periodically assess how the client and his/her family are functioning with this process. As occupational therapists using the occupational therapy (OT) process, specifically establishing the OT profile of function, it is important to understand the family relationships, support networks, and the role of the child. The occupational therapist's role after a traumatic injury includes providing information about the injury and the recovery process as well as offering information about community resources.

**Limitations**

The interviews were emotional for the family members and in turn for the investigator. An opportunity to do additional interviews with all of the participants would have provided an opportunity for the investigator to process her emotional response and then ask follow up questions. Also, if this additional round of interviews took place after the thematic analysis, more information could have been provided on the three major themes of pain, change, and miracles.

**Future Research**

In retrospect, it would have been interesting to have the family and the CHT journal throughout the rehabilitation process in order to see how the changes in the family members and the family as a unit correspond with the healing process, patient reports of pain, and the development of recovery in the arm.

**Conclusions**

The purpose of this study was to gain an in-depth perspective on the experience of replantation and the subsequent rehabilitation process through the point of view of the 15 year old patient, his parents, his sister, and the treating CHT. The results demonstrate that the patient's as well as the family's perspective of the recovery and rehabilitation process are important to consider and to evaluate when practitioners are providing rehabilitative services. The healthcare practitioner needs to keep in mind that coping after a traumatic accident is a family process and all of the family members will experience this process differently. A certified hand therapist is in a unique position to provide treatment and emotional supports that the patient and family need after experiencing trauma such as the replantation of an amputated limb. As Tom explained "I looked

forward to [hand therapy] everyday... when I saw [my CHT] it made me realize that I was going to get better and that I could work hard with her and my arm would eventually come around.”

After a total of five surgeries and 87 hand therapy sessions, Tom has regained function in his replanted arm using it as a helper hand to assist his uninvolved hand during tasks such as lifting and carrying objects. Tom is an excellent example of resilience and positive changes despite the trauma he experienced at a young age. Tom and his family will continue to be an inspiration for others.

## References

- Battiston, B., Tos, P., Clemente, A., & Pontini, I. (2007). Actualities in big segments replantation surgery. *Journal of Plastic, Reconstructive, & Aesthetic Surgery, 60*, 849-855.
- Buschman, P. R. (1988). Pediatric orthopedics: Dealing with loss and chronic sorrow. *Loss, Grief, and Care, 2*, 39-44.
- Chan, S. W., & LaStayo, P. (2003). Hand therapy management following mutilating hand injuries. *Hand Clinics, 19*, 133-148.
- Chen, Z. W., Meyer, V. E., Kleinert, H. E., & Beasley, R. W. (1981). Present indications and contraindications for replantation as reflected by long-term functional results. *Orthopedic Clinics of North America, 12*, 849-870.
- Chew, W. Y., & Tsai, T. M. (2001). Major upper limb replantation. *Upper Extremities Amputations and Management of Acute Microsurgical Treatment: Prostheses and Rehabilitation, 17*, 395-410.
- Dagum, A. B., Slesarenko, Y., & Winston, L. (2007). Long-term outcome of replantation of proximal-third amputated arm: A worthwhile endeavor. *Techniques in Hand and Upper Extremity Surgery, 11*, 231-235.
- Garner, R. (1988). Upper limb replantation: Does the patient benefit? *British Journal of Occupational Therapy, 51*, 228-231.
- Hammell, K. W., Carpenter, C., & Dyck, I. (2000). *Using qualitative research: A practical guide for occupational and physical therapists*. London, England: Churchill Livingstone.

- Hudal, P. L., Amadio, P. C., & Bombardier, C. (1996). Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder, and hand). *American Journal of Industrial Medicine, 29*, 602-608.
- Koul, A. R., Cyriac, A., Khaleel, V. M., & Vinodan, K. (2004). Bilateral high upper limb replantation in a child. *Plastic and Reconstructive Surgery, 113*, 1734-1738.
- Kumar, A. R., Grewal, N. S., Chung, T. L., & Bradley, J. P. (2009). Lessons from the modern battlefield: Successful upper extremity reconstruction in the subacute period. *The Journal of Trauma, Injury, Infection, and Critical Care, 67*, 752-757.
- Papanastasiou, S. (2002). Rehabilitation of the replanted upper extremity. *Plastic and Reconstructive Surgery, 109*, 978-981.
- Punamaki, R. J., Qouta, S., Sarraj, E. E., & Montgomery, E. (2006). Psychological distress and resources among siblings and parents exposed to traumatic events. *International Journal of Behavioral Development, 30*, 385-397.
- Raimondi, P. L., Petrolati, M., & Delaria, G. (2000). Replantation of large segments in children. *Pediatric Upper Extremity, 16*, 547-561.
- Russell, R. C., O'Brien, B., Morrison, W. A., Pamamull, G., & Macleod, A. (1984). The late functional results of upper limb revascularization and replantation. *Journal of Hand Surgery, 9*, 623-633.
- Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and social sciences* (3<sup>rd</sup> ed.). New York, NY: Teachers College Press.
- Scheker, L. R., & Hodges, A. (2001). Brace and rehabilitation after replantation and revascularization. *Hand Clinics, 17*, 473-480.

- Silverman, P. M., Willette-Green, V., & Petrilli, J. (1989). Early protective motion in digital revascularization and replantation. *Journal of Hand Therapy, 2*, 84-101.
- Vennelle, A. (1988). Therapy following replantation of a hand. *British Journal of Occupational Therapy, 51*, 232-235.
- Ware, J. E., Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36 ®): conceptual framework and item selection. *Medical Care, 30*, 473-283.
- Wei, F. C., & Mardini, S. (2003). Discussion: Bilateral high upper limb replantation in a child. *Plastic and Reconstructive Surgery, 113*, 1739-1741.

## Appendix

### Interview Protocol for the 15 year old with the replanted upper extremity.

**Guide for Interview 1.** Script for interviewer: First of all, I want to thank you for participating in this study. I will be taking some notes during the interviews as well as audio recording the sessions. I just want to remind you that it is your right to choose to not answer any question. The purpose of this first interview is to understand what your life was like before your arm was reattached.

Question 1. Describe to me what your eighth grade year was like.

Probes:

- a). Describe for me what a typical day was like before the accident.
- b). What after school activities did you like to participate in?
- c). Did you play any sports?
- d). Did you ever win any awards for your participation in sports?
- e). What did you want to be when you grow up?

Question 2. What friends did you like to hang out with?

- a). What did you like to do with them?
- b). Did you have a girlfriend?

Question 3. Did you have chores that you did at home?

- a). Did you have a job?
- b). What kind of clothes did you like to wear?
- c). Did you do your own laundry?

Question 4. Tell me what your family was like?

- a) What did you like to do with your Dad? Emily? Mom?
- b) What did you do together as a family?

**Protocol for Interview 2.** Script for interviewer: Last time we talked about what your life was like before the accident. The purpose of this second interview is to understand what your experiences of the surgery to reattach your arm and therapy that followed. I just want to remind you that it is your right to choose to not answer any question. Please let me know if you would like to take a break.

Question 1. (What happened the day of the accident?) Can you tell me about your experience of being in the accident?

Probes: (Who, what, when, where and why?)

- a). Were you scared?
- b). Where was your family?
- c). Who rescued you?
- d). What were people reactions on the shore?
- e). How did you get to the hospital? How did your family get to the hospital?

Question 2. Explain to me what was it like to have your arm reattached?

Probes: Were you surprised when you woke up out of surgery and found your arm reattached?

What did it feel like? Like your arm?

- a).What questions did you have after the your arm was reattached?
- b).What were worried about?
- c). What was your pain like in the days right after the surgery?
- d). Who was at the hospital with you?
- e). What did you think the first time you saw your arm without bandages?
- f). Did you have any other injuries?
- g). Skin graft

Question 3. Tell me about your experience of hand therapy

Probes:

- a). How often did you go to hand therapy?
- b). What did they do there? Exercises, etc.?
- c). What was the pain like?
- d). Did you want to go to therapy?
- e). What did it feel like? (sensation of the arm)
- f). What was it like when you saw your arm move for the first time?
- g). What was the worst thing about the therapy?
- h). What was the best thing about the therapy?
- e) Did you feel like your ideas and opinions were taken into account?

Question 4. Did you see any one else other than your CHT and surgeon about you arm?

Question 5. Tell me about a typical day for you was like right after the accident?

- a). Was your sleep affected? What was the pain like?
- b). Were you able to take care of your self? (dress your self, wash your hair, etc?)

- c). What was your wound care routine? (did you do it or did someone else)
- d). Did you return to work? When he returned to work?
- e). How soon after you got home from the hospital did you friends come over?  
What did you do with your friends?

**Protocol for Interview 3.** Script for interviewer: Last time we talked about what your experiences of the replantation and rehabilitation were like. The purpose of the third interview is to understand how the injury has affected the various aspects of your life. I just want to remind you that it is your right to choose to not answer any question.

Question 1. At the end of your eighth grade year and the beginning of summer, what were you expecting of high school? What were you looking forward to?

Question 2. Has anything changed for you since the accident?

Probes:

- a). What has changed for you since the accident?

Any changes in the activities you participate? Life goals? Social networking? Self care routines? Driving? Chores?

- b). How has the accident changed your family or family life?

- Chores and home expectations?
- Do your parents or sister help you with anything still?
- c) What was it like being interviewed in the hospital? What was it like having your pictures taken? Who interviewed you (newspapers, news channels, etc.)
- d) Has it changed any of your relationships? With family? Friends?
- e) Do you feel like your parents treat you differently?

Question 3. What is a typical day like for you now?

Question 4. What do you want to do after high school?

Probe:

- a). What do you want to be when you grow up?

Question 5. In our last interview you were telling me about the dream you had the first night at home after the accident? Have you had that dream again?

Question 6. Did you ever get angry about the accident? How did you deal with that anger? Is it hard for you if other people are angry towards the boat driver?

Question 7. How do you keep motivated?

Question 8. If you could change one thing about this situation what would it be? What positive things have you seen come out of this experience?

Question 9. If there was anything you would want to have happened differently in hand therapy what would it be? Your experience in the hospital?

Question 10. What would you recommend for someone else who just went through surgery to reattach their arm?

Question 11. What would you recommend for a hand therapist who is treating a patient after surgery to reattach his/ her arm?

Probes:

a). What helped you get through the therapy sessions? Through the pain?

Question 12. How did you cope with the accident? What or who helped you?

Question 13. How do you feel about the outcome of your arm? How do you feel about the scar?

Question 14. Is there anything else that you feel needs to be addressed or that you would like to add?

Thank you for participating in these interviews. Please let me know if you have any questions.

### **Interview Protocol for the Parents**

Script for interviewer: First of all, I want to thank you for your participation in this study. I will be taking some notes during the interviews as well as audio recording the sessions. I just want to remind you that it is your right to choose not to answer any questions.

The purpose of this interview is to understand what the experience of your son's accident and the rehabilitation process has been like for you.

Question 1. What was family life like prior to the accident?

Typical routines? What did you like to do together as a family? What did you like to do with your son? Did Tom have any chores or household responsibilities? Was Tom independent in taking care of himself?

Question 2. Talk to me about your feelings of the accident and the rehabilitation process.

Probe:

a). How did you find out about your sons accident?

What were your initial feelings?

What did you think when you saw him?

How did he get transported to the hospital?

How did you get to the hospital?

What questions did you have after the accident and the surgery?

What was the experience like of watching your child going through hand therapy?

a). What did you hope to gain from hand therapy?

b). What was the best thing about your child participating in hand therapy? The worst thing?

c). What were you thinking when you were watching?

What was it like having to do the dressing changes and exercises daily?

Question 3. How has life changed since the accident?

How much did you have to help him after the accident? Now?

How did you cope with the accident? How did your family cope with the accident? Tom?

What was it like to have your son's case publicized?

Question 4. How do you feel about the outcome his arm? What were your thoughts when you first got to see his arm move?

Question 5. What would you recommend for a family whose child just went through surgery to reattach his/ her arm?

Probes:

Where to find resources? What to look for in a therapist?

Question 5. In published literature, researchers report that the patient's active participation and motivation during the long rehabilitation process is necessary for successful recovery after the reattachment of a limb. How would you describe your son's motivation? Did you do anything to help him stay motivated?

Question 6. In the literature, it is also reported that the close collaboration with the surgeon and the patient is crucial for successful recovery.

Who was on the "team." Did you have a good relationship with the surgeon? The hand therapist? Did they keep you in the loop on things?

Question. How would you describe the CHT's role in the recovery process?

Probes:

Help with the day to day questions?

Question. How would you describe the outcome of Tom's arm?

Question 7. Is there anything that you feel needs to be addressed or you would like to add?

Thank you for participating in this interview. Please let me know if you have any questions.

### **Interview Protocol for the Certified Hand Therapist**

Script for interviewer: First of all, I want to thank you for your participation in this study. I will be taking some notes during the interviews as well as audio recording the session. I just want to remind you that it is your right to choose not to answer any question. The purpose of this interview is to understand what your experience of treating the patient's upper extremity replantation was like.

Question 1. Why did you choose to become a CHT? (because not very many physical therapists are CHTs)

Question 2. Have you ever treated an upper extremity replantation before?

Question 3. What was it like to treat an adolescent who has experienced this level of injury?

Question 4. What were the challenges of working with this patient? Rewards?

Probes:

What about working with the family... challenges and rewards?

How did you motivate him?

What interventions did you use? Did you address any self care activities or routines?

What was the most successful intervention? What didn't seem to work for him?

Question 5. In published literature, researchers report that the patient's active participation and motivation during the long rehabilitation process is necessary for successful recovery after the reattachment of a limb. What are your thoughts on this statement?

Probes:

How much do you think his level of motivation affected his outcome?

How do you think his mental state affected his ability to participate in therapy?

Question 6. In the literature, it is also reported that the close collaboration with the surgeon and the patient is crucial for successful recovery. What are your thoughts on this statement?

Probes:

How would you describe the collaboration between you and the patient?

- Communication with the family?
- Communication with the medical team?
- Any other team members?

Question 7. Is there anything you would recommend for another hand therapist working with this level of injury?

- How to approach the patient?

Question 8. What advice for a patient just out of replantation surgery?

- Finding/ needing support?
- What to look for in a rehab. facility? In a hand therapist?

Question 9. Describe for me what the patient's outcome is?

Probes:

Functionality?

Question 10. Is there anything else that you feel needs to be addressed or that you would like to add?

### **Interview Protocol for the Sister**

Script for interviewer: First of all, I want to thank you for your participation in this study. I will be taking some notes during the interviews as well as audio recording the sessions. I just want to remind you that it is your right to choose not to answer any questions. The purpose of this interview is to understand what the experience of your brother's accident and the rehabilitation process has been like for you.

Question 1. What was family life like prior to the accident?

Typical routines? What did you like to do together as a family? What did you like to do with Tom?

Question 2. Talk to me about your feelings of the accident and the rehabilitation process.

Probe:

- a). How did you find out about your brother's accident?

What were your initial feelings?

What did you think when you saw him?

How did he get transported to the hospital?

How did you get to the hospital?

What questions did you have after the accident and the surgery?

What was it like to have your brother's case publicized?

What was the experience like of watching your brother going through hand therapy?

a). What were you thinking when you were watching?

b). What was like having the family make time to do the dressing changes and exercises every day? Change anything for you?

Question 3. How has life changed since the accident?

How much did you have to help him after the accident? Now?

How did you cope with the accident? How did your family cope with the accident? Tom?

Do you feel like you have been treated differently since the accident? By your parents?

By Tom? Do you feel like you treat Tom differently?

What do you and Tom do together now?

Is there anything that you have done that you might not have before the accident?

(College essay, Girls' State)

Question 4. How do you feel about the outcome his arm? What were your thoughts when you first got to see his arm move?

Question 5. What would you recommend for someone whose sibling just went through surgery to reattach his/ her arm?

Probes:

How to approach the family?

Question 6. In published literature, researchers report that the patient's active participation and motivation during the long rehabilitation process is necessary for successful recovery after the reattachment of a limb. How would you describe Tom's motivation? Did you do anything to help him stay motivated?

Question 7. Is there anything that you feel needs to be addressed or you would like to add?

Thank you for participating in this interview. Please let me know if you have any questions.

Table 1

Range of motion measurements of the replanted arm 1.5 years after surgery

---

Elbow extension/ flexion	28°/ 135°
Pronation/ Supination	40°/35°
Wrist flexion/ extension (with gravity assisted extension)	80°/50°
Wrist extension against gravity (measured on the ulnar border)	35°

---

*Note.* Measurements were obtained using a 360° goniometer with a 1° increment change

Table 2

Range of motion measurements of the involved hand 1.5 years after surgery

	Thumb	Index	Middle	Ring	Small
MCP	22°/50°	0°/65°	0°/75°	+15°/75°	0°/65°
PIP		3°/95°	50°/105°	85°/105°	15°/90°
DIP	+5°/50°	5°/60°	5°/30°	6°/50°	12°/70°

*Note.* Measurements obtained using a 180° goniometer with a 1° increment change. The measurements represent extension/ flexion of the various joints in the fingers and thumb.

Table 3  
Strength of the involved hand

	Right	Left (involved)
Grip	90 lb	17 lb
Two-point pinch	15 lb	1 lb
Lateral pinch	20 lb	3 lb

*Note.* Patient was wearing a wrist brace to keep his wrist in a functional position. A standard dynamometer and pinch meter were used to measure strength.

Figure 1. The Meaning of the Accident for the Adolescent Patient

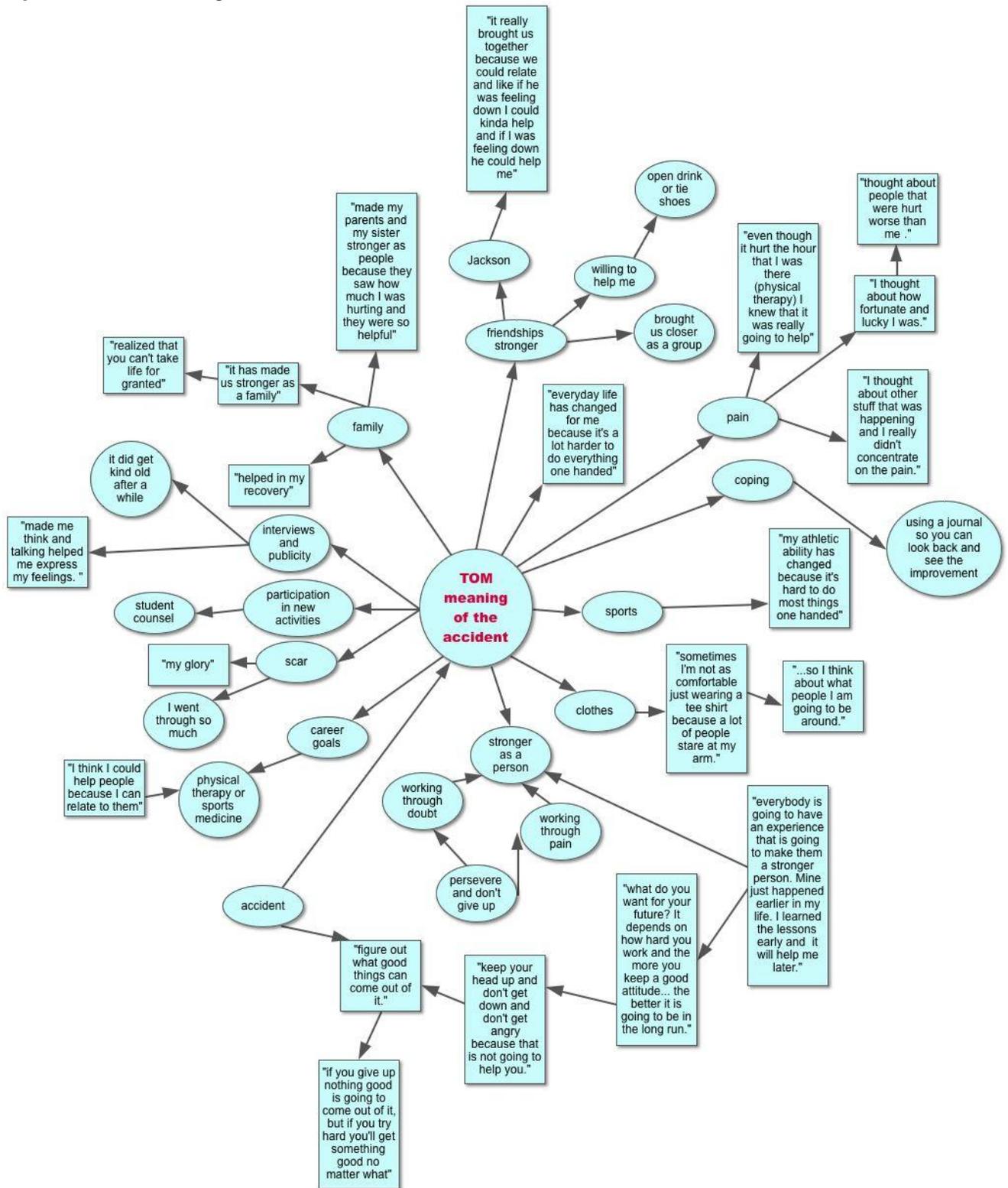


Figure 1. This Inspiration© web is the product of the thematic analysis of the third interview with Tom.

### Acknowledgements

I would like to express thanks to my committee, Lucretia Berg, Martins Linauts, and Cathy Elvins for their careful reading and guidance for this project. I would also like to show gratitude to Tom and his family for inspiring me and for providing constant support. Last but not least, I would like to acknowledge Julie Berridge for being my mentor and for providing me with insight into the world of hand therapy.