FUNCTIONAL OUTCOMES IN PATIENTS WITH FULL THICKNESS HAND BURNS

by

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THESIS

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ABSTRACT
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Background: There has been previous work objectively examining the severe contractures that develop with hand burns, but few have correlated severity with functional outcome. While contracture definitions exist for restrictions in range of motion (ROM), they have not been linked to prognostic use and functional outcome.

Objective: The objective of this study is to correlate severity of hand contracture in joints of the hand with differences in functional outcomes scores at discharge.

Methods: This multicenter study uses the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) database, otherwise known as the Burn Injury Model Systems (BMS) National Database. A sample of 95 patients with ROM measurements and the SF-36 physical component score (PCS) to measure functional outcome was used. Patients were grouped by ROM into mild, moderate, or severe contracture definitions. Inclusion criteria included those with burn injuries as defined by the American Burn Association who had recorded ROM deficits. Patients with post-injury amputations were excluded. Statistical analyses were conducted to compare the maximum severity of contracture in both hands on the PCS when the maximum contracture was classified as mild, moderate, or severe. Secondary analysis was used to also compare PCS between mild and moderate versus severe contracture groups.

Results: There was no significant difference in PCS for mild, moderate or severe contracture ($p = 0.858$). There was a downward trend noted in the means between each contracture group, as well as several outliers in the moderate contracture group. Secondary analysis between a combined mild and moderate versus severe contracture group showed no significant difference in PCS between the two groups ($p = 0.654$)

Conclusion: The results of this study suggest that although there is a downward trend in PCS that correlates with severity of contracture, the difference in functional outcome as measured by the PCS is not significant between the different ratings of contracture severity. Future studies involving long-term PCS data and other functional outcome assays may allow us to differentiate these contracture groups and guide rehabilitative interventions.

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CHAPTER 1: Introduction

The treatment of burns, particularly those of the hands, has greatly improved over the previous decades. Medical outcomes and burn survival rates have improved, but with this improvement comes a greater need to determine prognostic factors that lead to improved burn functional outcomes.[1] While the overall mortality of burn injuries has decreased with improved treatment, they are often associated with severe morbidity. The cost of treating burns and associated complications in major medical centers have steadily been increasing throughout the last 20 years, rising on average from around $2,000 a day in the 1980s to $5,000 a day. These costs arise from the increased level of care required to treat these injuries, as well as multiple surgeries and dressing changes to properly treat burns. The average international hospital cost of a burn patient at a major medical center was $88,218.[2] Burn incidence is not significantly associated with any specific demographic or socioeconomic class, thus affecting many levels of society in the US.[3,4]

Burn injuries commonly involve skin, muscle, tendons and bone at many joints, leading to the formation of contractures from scar tissue formation. One study by Kowalske et. al[5] found that 42% of adult burn patients develop contractures, with a majority of these contractures most frequently involving the hand, elbow, and shoulder joints.[6] Of these contractures, multiple studies have found that hand burn contractures rank as one of the most common areas of contracture formation, with up to 35% of all contractures involving the hand.[7] Of patients who do suffer hand burns, a study found that 16% developed hand contractures.[8] Despite significant advancements in burn care and treatment, the incidence of contracture formation in the hands after burn injury continues to be high.

The pathology of these contractures is complex. Vu et. al described the pathology of contracture formation as "multifactorial in nature, involving multiple pathological changes to the joints that limit overall range of motion. One contributing factor to burn contractures is the eventual dermal contraction of scar hypertrophy. Myofibroblasts in this scar tissue contract edges of the wound, leading to restriction of the joint limited by skin tension, often developing increased thickness after re-epithelialization after 5 weeks.[9] Another component of burn contracture is muscle and soft tissue contracture related to immobility and disuse of the joint.[10,11] Lastly, neuropathies that develop from damage to peripheral nerves can further exacerbate movement and sensation in the affected limb, potentiating the above factors.[12] Due to the complex contributors to contracture formation, management of these contractures is difficult, with conflicting perspectives on early surgical treatment or mobilization."[13]

The development of contractures may contribute to the abnormal function, decreased range of motion, and psychiatric disorders commonly seen in the burn survivor population. More recent research has shown that these contractures are functionally debilitating to burn survivors, with studies showing impaired range of motion, fine motor function, and activities of daily living (ADL).[14] Additionally, hand burns have been shown to play a large role in outcome related to societal, professional, and physical quality of life for burn survivors.[15,16] Burns in both hands have been found to account for an 85% decreased likelihood for a burn survivor to return to employment within 12 months of their burn injury, with only 37% returning to work without job modification[17] Holvanahalli et. al, using the Jebsen-Taylor Hand Function Test (JTHFT), found that patients with full dermal thickness hand burns struggled in tasks associated with common, discussed below.[18] One study found a significant increase in depression scores in patients with face and/or hand burns, as well as increased incidence of divorce and juvenile delinquency.[19]

There is significant evidence that hand burns can contribute to multiple aspects of social and health outcome after injury. Although hand burns are common in burn survivors, few studies have evaluated how range of motion of the upper extremities and hand relate to the functional prognosis of these patients.

It is clinically important, then, to determine factors that are correlated with the formation of hand contractures. Schneider et. al found a significant amount of patients (23%) developed hand contractures after a hand burn, with most contractures rated as mild or moderate in severity.[20] The formation of these contractures are most associated with flame and scald burns.[8] Multiple studies have found that length of hospital stay, extent of burn, and size of grafting increase the likelihood of contracture formation.[4,7] Other predictors of the formation and severity of contracture include graft size, amputation, inhalation injury, and 3rd degree burns.[4,6]

Studies examining early treatment and rehabilitation modalities have shown the overall effectiveness of rehabilitation of hand burns on functional outcomes.[21] An initial study by Cole et. al in 1992[22] found that in patients with deep partial thickness hand burns, long-term functional outcome did not significantly differ if an early surgical or conservative approach was taken. Rehabilitative interventions for hand burns consist of the use of early stretching, followed by splinting or serial casting of the hand joints to maintain range of motion. A small prospective study has also shown inpatient rehabilitation alongside treatment can also improve functional outcomes.[23]

Patient functional outcomes can be difficult to determine due to the unclear correlation between burn contracture characteristics and applicability of patient questionnaires. A recent review by Lin et. al on the available outcome measures of hand function shows inconsistency in the application and use of the available hand physical/component outcomes and performance

outcome measurements.[24,25] *Objective* physical/component measures are defined as the measurement of properties of the hand, such as grip strength and range of motion (ROM). Objective measures primarily offer reliable and repeatable measurements of contracture severity. This study is primarily interested in the use of ROM as a measure of evaluating burn contracture severity. Different definitions of contracture based on ROM have been used in the literature. Proposed by Johnson et. al[26] in 1980 and recommended by the American Society for Surgery of the Hand, active range of motion (AROM) uses the degree of flexion and extension of the hand's individual joints in a summated numerical value to objectively evaluate severity of contracture (Figure 1). Patients are split into "normal" and "poor" contracture formation. This paper primarily uses the Schneider et. al characterization of burn contracture (Table 2), as it allows a more nuanced definition of contracture. Contracture severity is rated by splitting expected range of motion into thirds, characterizing deficits in ROM as "mild", "moderate", and "severe".[20] The primary criticism of ROM in hand burns is that impairment of extension compared to flexion of digits may not be equivalent in terms of function.[24,27,28] Other objective hand function tests also exist. These hand performance measurements assess hand function by simulating ADL's. The Jebsen-Taylor Hand Function Test (JTHFT) is most commonly used to evaluate performance outcome through timed trials of seven different simulated ADL's.[29] Specifically, it examines performance of tasks such as turning over heavy cans, picking up index cards, and stacking checkers. van Zuiljan et. al examined the use of the JTHFT after full thickness hand burns for 12 months. Interestingly, over 80% of hands evaluated in the study regained long-term normal function as measured by the JTHFT.[14] Another test is the Functional Independence Measure (FIM) score, a standardized test typically used in a variety of rehabilitative settings.[30] It contains both a cognitive and motor section, making it useful as a way to measure function after burn

contracture on daily living activities. The motor subscale measures activities such as transfers, dressing, and eating and measures the amount of assistance needed on an ordinal scale from 1-7. The cognitive subscale depends on patient self-reported difficulty with areas such as comprehension, social interaction, and memory. Additionally, it has been proven to have reliability in the burn patient population in examining function.[31] The above tests and characterizations allow *objective* collection of quantitative data on the physical function of the digits of the hand, as well as further characterization of the severity of burns.

There are many *subjective* tests for the evaluation of function in the burn patient population. One test used to measure functional outcome and quality of life is the Short Form-36. This test is comprised of the physical component score (PCS) and mental component score (MCS). It depends on self-reported measures that are transformed into a 0-100 scale, with higher scores indicating less disability. It has reliability in determining quality of life outcomes after initial injury in the burn patient population.[32] Another questionnaire commonly used is the Functional Assessment Screening Questionnaire (FASQ). This 15-item survey is commonly used for ADL's of the upper extremity, including personal care, leisure, occupational and instrumental activities, and transportation. The FASQ is commonly used in the burn population as a reliable measure of function.[33] These subjective measures of function in burn patients can be used in this study to determine the functional severity of reduced range of motion in hand burn contracture.

Additionally, there has been new research using other measures of outcome to quantify functional outcome in this patient population. A literature search returned one related study by Niedzielski et. al[34] who examined the use of AROM in the development of a proposed burn scar contracture severity scale (BSC-SS) and another by Leblebici et. al[16] who correlated decreased AROM with worsened scores on psychosocial quality of life surveys. Both studies found

correlations between increased contractures number and severity, as measured and defined by AROM, and non-performance measures of functional outcomes.

The relationship between these objective tests, subjective tests, and the rehabilitative prognosis of burn survivors requires further evaluation. Previous work done by Holavanahalli et. al[18] initially showed that 40% of study subjects with deep thickness hand burns had AROM measurements and JTHFT scores that were significantly lower than normative values. Even with this decrease in function, Sheridan et. al found that 90% of patients with variable thickness hand burns retained normal ADL and function.[35]

Preliminary analysis by Vu et. al[36] supports this initial decrease in functional outcomes after burn injury, having found a significant decrease in functional outcomes after hand burn injury at hospital discharge. A sub-sample of 26 patients from the Dallas study site of the BMS database with full AROM measurements was included in this study. AROM were graded according to American Society of Hand Surgery guidelines, with AROM < 180 in the main digits and AROM < 100 in the thumb rated as "poor", These "poor" AROM definitions are associated with significant difficulty with achieving adequate range of motion from normal. Patients, on average, suffered from around 3.1 contractures per hand, with significant contractures relating to the thumb. This preliminary data also included hand burn patients (n = 11) with available functional outcome records and SF-36 scores at discharge. Scores in patients (n = 11) with severe hand burns were significantly lower after injury, with patients rating their average functional outcomes with a cumulative score of 39.6 pre-burn and 34.5 post-burn (p = 0.034). The tables and figures associated with these results have been reproduced below (Table 1 and Figure 2). These previous results suggest that worsened AROM measurements may lead to decreased functional outcomes.

This study primarily aims to further examine the use of ROM to describe the relationship between contracture severity and patient functional outcomes using the SF-36. This relationship has not been thoroughly examined in the literature and would be of prognostic utility in hand burn injury. Utilizing the national multicenter BMS database, this study will aim to 1) report the incidence and severity of ROM deficits of the burn injured hand and 2) examine functional outcome following hand burns at discharge as measured by the SF-36. We hypothesize that patients with hand burns who present with more severe contractures will have a significant difference between PCS measured at discharge.

CHAPTER 2: Study Design

The data for this study is part of the large multicenter NIDILRR/BMS database. Patients were consented for this study over the course of 1997 – 2006. The data collected as part of this study includes demographic data such as age, length of hospital stay, and occupation. Burn injury characteristics such as total body surface area (TBSA) of the burn, TBSA grafted, amputations, and ROM were also collected. The independent variable in this study is defined as the presence of mild, moderate, or severe contracture in either or both hands. The primary outcome measure is the PCS of the SF-36 survey score taken within one week of discharge. Patients were consented for use of their hospital, demographic, and burn characteristic data as part of the BMS national database. Inclusion criteria for all these groups are patients age 18 or older with major burn injury as defined by American Burn Association guidelines, with presence of any degree of finger joint contracture. Exclusion criteria included presence of finger or hand amputations and unavailable SF-36 data at discharge. Amputations were excluded due to their unknown and likely confounding effect on burn survivor functional outcomes in our analysis of contracture severity's effects.

In this study, ROM is defined in degrees of motion. Each measurement uses the preceding plane of the finger phalanx bone to define 0 degrees of flexion or extension. Maximal flexion ROM at the metacarpal, proximal interphalangeal (PIP) joint, and distal interphalangeal joint (DIP) is measured. Similarly, maximal extension ROM at the metacarpal, PIP joint, and DIP joint is measured. Lack of extension is defined as the remaining possible extension in degrees to reach 0 degrees or full normal extension in each joint. All ROM measurements were taken using goniometer by trained physical therapists. A standard data dictionary was developed for use by therapists to maintain data reliability.

To examine the physical functional outcomes in this sample, this study uses the PCS, separated into 4 subcategories of physical functioning, physical roles, bodily pain, and general health perception. These categories include questions on how health affects ADL's such as exercise, lifting groceries, climbing stairs, extended walking, etc. The SF-36 has reliability in determining quality of life outcomes after initial injury in the burn patient population.[32] Normative values for subcategories of the PCS are roughly 78.8 – 92.5, and for the population of patients with chronic illness average 60.8 – 78.3.[37]

This study splits the patient sample into 3 different groups for comparison: mild (n = 7), moderate (n = 45), and severe (n = 43) contracture. Patients ROM in each individual finger joint (MCP, PIP, DIP) on both hands were categorized as "mild", "moderate", and "severe" according to the provided ROM definitions as reported by Schneider et. al presented in Table 1. Both hands of patients were then categorized by the highest severity of contracture present. For example, a patient with two right hand mild contractures and one left hand moderate contracture would be categorized in the "moderate" contracture group. Homogeneity of variances and standard deviation were confirmed in the sample data. However, the normalcy of the data across all separate groups of contractures could not be confirmed. Non-parametric Kruskal-Willis one-way analysis of variance (ANOVA) was conducted to compare the effect of contracture severity on functional outcomes as measured by the PCS for mild, moderate, and severe contracture. Secondary analysis also examined the difference in means between that of the combined "mild and moderate" and "severe" contracture group using a Mann-Whitney t-test. A significance level of $p = 0.05$ was used to determine significance. Refer to Figure 3 for detailed breakdown in patient sampling.

CHAPTER 3: Results

Population and Hospital Stay Characteristics:

On average, this sample (n = 95) was primarily young Caucasian males. Length of stay was on average 26 days, with overall TBSA burned and grafted at 22.4% and 11.5%, respectively. 83.6% of patients in this study right hand dominant. Refer to Table 3 for further demographic data breakdown.

Contracture Characteristics:

Of the 95 patients who were sampled for this study, 48% of patients had contractures in both hands. On average, limitation of flexion ROM was the most frequently occurring contracture throughout each finger joint in the hand. While the average ROM for extension was near normal values per this study's definition of contracture, flexion was often limited. Left hands most frequently suffered from moderate or greater contractures. Right hands most frequently suffered from severe contractures. Refer to Tables 4 and 5 for detailed contracture descriptive statistics.

Comparison of Severity Contracture on Functional Outcome

Patients were divided into mild (n = 7), moderate, (n = 45), and severe (n = 43) contracture groups based on ROM values. A one-way Kruskal-Wallis ANOVA was conducted to compare the maximum severity of contracture in both hands on the PCS when the contracture was classified as mild, moderate, or severe. There was no significant difference in PCS between any severity of contracture ($p = 0.858$). There was a downward trend noted in the means between each contracture group, as well as several outliers in the moderate contracture group. Overall,

these results suggest that the contracture of severity do not influence overall functional outcome. Refer to Tables 6 and 7 for detailed Kruskal-Wallis test breakdown.

Secondary analysis compared the combined mild and moderate contracture group against the severe contracture group. A Mann-Whitney T-test was used to compare the maximum severity of contracture in both hands on the PCS when the contracture was classified as mild and moderate versus severe. There was no significant difference of PCS between the two contracture severity groups ($p = 0.654$). Refer to Tables 8 and 9 for detailed Mann-Whitney test breakdown Our results suggest that there is no significant difference in PCS between those with contractures of differing severity. While the mean PCS for each of these contracture severity groups do follow a downward trend and are below typical normative values, they do not differ significantly between each group in this study.

CHAPTER 4: Conclusion

Previous papers have suggested that severity of contracture is not a practical measure of hand burn outcomes due to the difficulty in determining the functional significance of flexion versus extension. Our study hoped to examine evidence contracture severity's use in contracture functional prognosis. The results of this study suggest that, while there is a downward trend in functional outcome as measured by the SF-36 that correlates with severity of contracture, the difference in functional outcome as measured by the PCS is not significant between the different ratings of contracture severity. We suspect that these differences between contracture severity populations at discharge are likely, but that this study did not have the power needed to determine a significant difference. The "mild" contracture group of this study had a reduced number of patients available (n = 7) compared to the moderate and severe groups (n = 45, n = 43), which may affect the statistical tests utilized. When comparing the separation of this study sample into 3 (mild, moderate, severe) or 2 (mild and moderate, severe), neither had differences in means between comparison groups that were significant. We suspect the lack of patients in the mild contracture group may be due to both the increased prevalence of moderate to severe contracture in the BMS database, as well as the method used to determine the separate study groups. Patients with multiple mild contractures and one severe contracture would be rated as "severe". The contribution of multiple mild contractures in the presence of severe contracture to functional outcomes is unknown. Additionally, these contractures were not examined in the context of the dominant hand of the patient. While most of the contracture formation and handedness of the patient was in the right hand, our study did not examine whether contracture formation in the specific dominant hand of the patient was related to a worsened functional

outcome at discharge. This relationship could be a focus of future studies, as the dominant hand could play a more significant role in ADL's.

There are other limitations to this study that may limit its generalizability and the conclusions drawn from these results. Subjective measures of functioning depend on self-reporting, which could affect the reliability of these outcome measures. The PCS specifically asks patients about broad aspects of ADL's, such as their ability to conduct vigorous activities, bathing, dressing, moderate activities, and mobility. This measure may not adequately encompass the typical ADL's burn survivors struggle with, especially those pertaining to hand function. Patients data used in this study were collected from 1997 – 2006, and thus new advancements in burn care and rehabilitation may have some effect on their functional outcome scores at discharge.

The difficulty in objectively examining hand contracture arises from the uniqueness of patients' contracture and future adaptive functioning after this injury. We hypothesize that functional outcome is too complex to be adequately summarized by contracture severity. In our clinical experience, patients with similar contracture definitions can exhibit markedly different functional trajectory in later rehabilitation. This study measures PCS score at discharge, and it may be that functional outcomes may differentiate themselves further along patients' rehabilitative timelines. These results suggest that patients with burn contractures start with similar capability for function at discharge regardless of the severity of their contracture. While the definitions of contracture severity in patients may be useful in describing burn lesions clinically, this study has not confirmed its utility determining function at discharge.

Another potential hypothesis for the similarity in functional outcome measured at discharge is the adaptability of patients to their hand contractures. Clinically, patients are often

able to adapt to ADL's affected by their hand contracture by utilizing their upper extremities in unique ways. Some of these ways include use of the wrist or elbow joint to grasp objects, or dependence on the upper extremity non affected by contracture. Patients can also utilize orthotics to augment their current level of function. The use of orthotics in burn injuries and their affect on functional outcome is another potential area of future research.

This study raises important questions for patients with hand burns. Rehabilitative interventions targeting specific ADL's described using the PCS could be useful in developing treatment protocols for patients after burn injury. However, more specific measures of hand outcomes such as the FASQ may be considered for future studies to allow great sensitivity and examination of ADL's influenced by hand function. Additionally, the JTHFT may provide insight into objective functional outcome data through its use of ADL time trials. Future studies may be able to look at models of contracture data that would best simulate the contribution of each individual finger contracture to functional outcome, as well as to determine a different method to weight contracture severity to allow more specific use of contracture severity grading for prognosis. The BMS database also contains outcome survey data at several later timepoints after discharge. Examining longitudinal outcomes for these patients may lead to further information on the contracture functional outcomes and rehabilitative potential these patients may possess.

LIST OF TABLES:

Table 1: *Preliminary Data of AROM in Individual Digits*

Table 2: Total Active Range of Motion Measurements

	Right Hand (n =20)				
	Thumb	Index	Middle	Ring	Little
Average total active motion (TAM)	48.6	181.95	191.3	189.5	179.6
Standard deviation of TAM	24.1	80.2	61.3	60.5	60.6
Number of "poor" contractures	20	9	6	8	10

	Left Hand (n = 16)				
	Thumb	Index	Middle	Ring	Little
Average total active motion (TAM)	27.4	152.8	169.9	166.4	147.7
Standard deviation of TAM	16.7	45.1	48.9	16.7	59.4
Number of "poor" contractures	16	11	9	10	11

Table 2: *Definitions of Mild, Moderate, and Severe Contracture**

		Contracture Severity (ROM in Degrees)		
Joint	Motion	Mild	Moderate	Severe
MCP	Flexion	60 – 89	30 – 59	0 – 29
	Extension	-1 – -30	-31 – -60	-61 – -90
PIP	Flexion	67 – 99	34 – 66	0 – 33
	Extension	-1 – -33	-34 – -66	-67 – -100
DIP	Flexion	47 – 69	24 – 46	0 – 23
	Extension	-1 – -23	-24 – -46	-47 – -70
Thumb IP	Flexion	48 – 69	24 – 47	0 – 23
	Extension	-1 – -23	-24 – -46	-47 – -70

*reproduced from Schneider et. al[20]

Table 3: *Demographic and Injury Characteristics of Study Sample*

Total number of patients	95
Male, percent	78
Age at injury, mean (SD) years	38.9 (10.9)
Ethnicity, percent	
Caucasian	72.6
Hispanic	6.3
Black	18.9
Other	2.1
Length of stay, mean (SD) days	26
Percent TBSA burned, mean (SD)	22.3 (18.2)
Percent TBSA grafted, mean (SD)	11.5 (12.8)
Right hand dominant, percent	86.3%

Table 4: *Average Range of Motion Measurements in Degrees*

		Left Hand (n = 69)				
		Thumb	Index	Middle	Ring	Little
MCP	Flexion	40.9	59.6	61.0	57.3	53.8
	Extension	2.6	5.5	5.3	6.6	4.9
PIP	Flexion	45.5	68.6	67.7	71.0	67.0
	Extension	4.2	-0.1	2.7	0.0	-1.7
DIP	Flexion		40.2	47.1	43.0	43.6
	Extension		-0.5	0.3	0.8	-1.8

		Right Hand (n = 75)				
		Thumb	Index	Middle	Ring	Little
MCP	Flexion	39.5	58.8	59.3	55.0	50.4
	Extension	4.2	2.6	3.2	2.6	6.3
PIP	Flexion	43.8	66.6	68.5	68.4	65.9
	Extension	5.4	-3.5	0.0	-0.7	0.2
DIP	Flexion		41.0	40.8	36.7	37.0
	Extension		-0.2	-1.7	-1.0	1.1

Table 5: *Number of Contractures by Severity in Sample*

	Left Hand (n = 69)					
	Thumb	Index	Middle	Ring	Little	Max
Mild	10	73	72	57	57	13
Moderate	14	65	55	59	61	38
Severe	6	15	10	14	19	16

	Right Hand (n = 75)					
	Thumb	Index	Middle	Ring	Little	Max
Mild	23	75	75	65	61	4
Moderate	51	79	86	71	70	33
Severe	31	21	18	29	37	37

Table 6: *Kruskal-Wallis Ranks*

	N	Mean Rank
Mild	7	52.29
Moderate	45	48.67
Severe	43	46.60
Total	95	

Table 7: *Kruskal-Wallis Test Statistics*

	PCS
H	0.306
df	2
Sig	0.858

Table 8: *Mann Whitney Ranks*

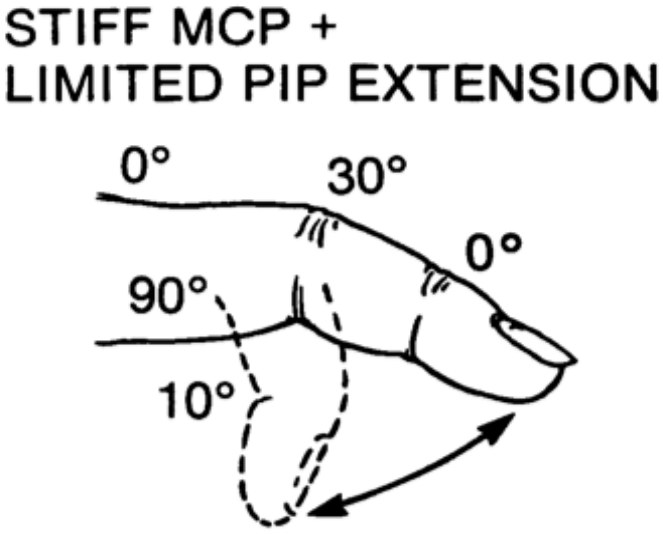
	N	Mean Rank	Sum of Ranks
Mild + Moderate	52	49.15	2556
Severe	43	46.60	2004
Total	95		

Table 9: *Mann-Whitney Test Statistics*

	PCS
Mann-Whitney U	1058
Wilcoxon W	2004
Z	-0.449
Sig	0.654

LIST OF FIGURES

Figure 1: *AROM Measurement Calculation**



Stiff MCP + Limited PIP Extension

Active	Flexion	Extension Lack
MCP	0°	0°
PIP	90°	30°
DIP	10°	0°
Totals	100°	30°

Total Active Motion (TAM)
100° – 30° = 70°

*****reproduced from Johnson et. al[26]

Figure 2: *Preliminary Data of SF-36 Scores Pre and Post Hand Burn Injury*

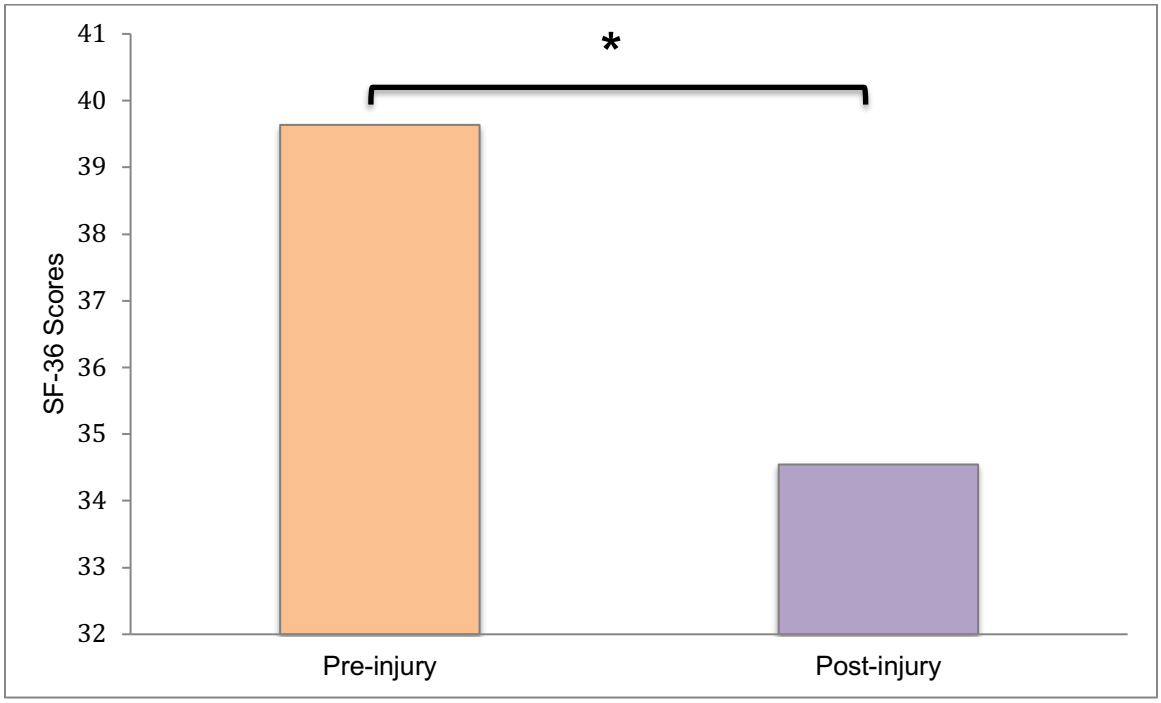


Figure 3: *Flow Chart of Study Sample Selection*

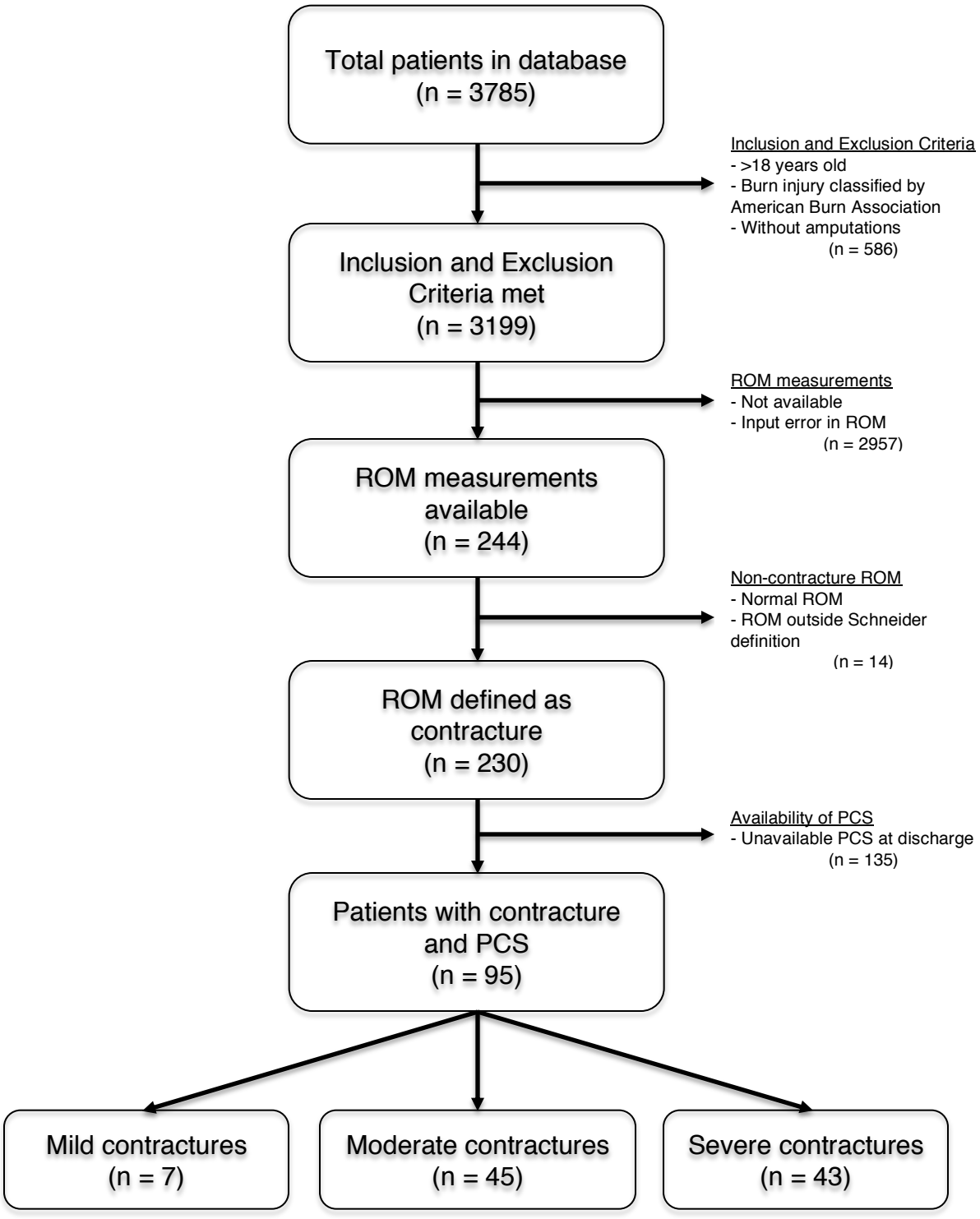


Figure 4: *Box Plot of SF-36 Score Categorized by Contracture Severity (mild, moderate, severe)*

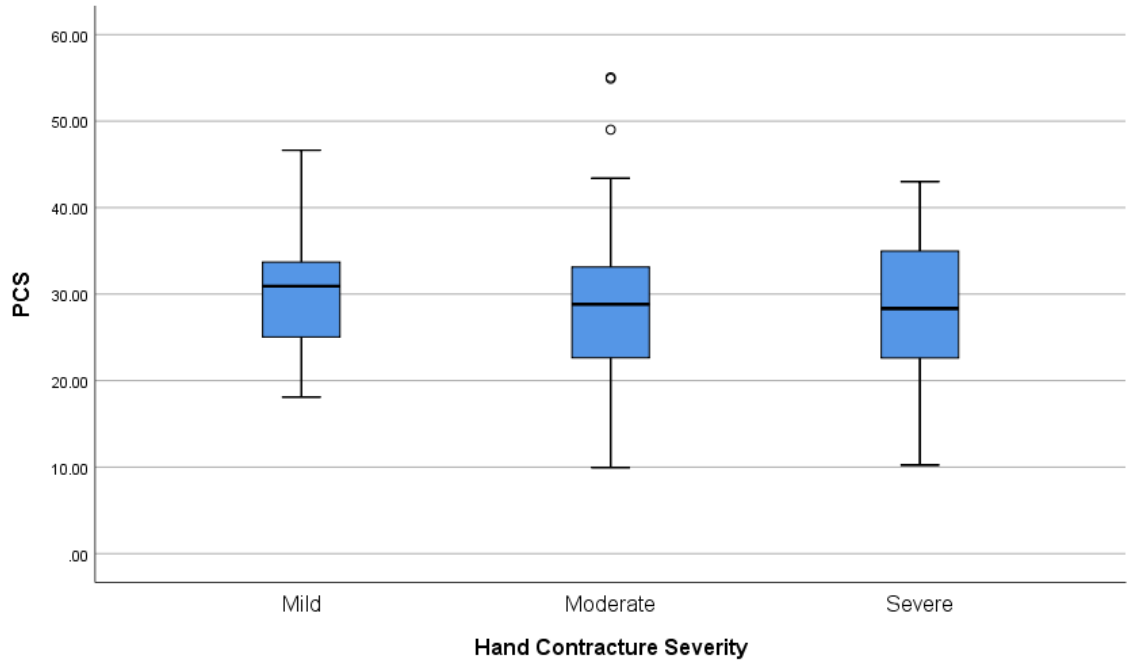
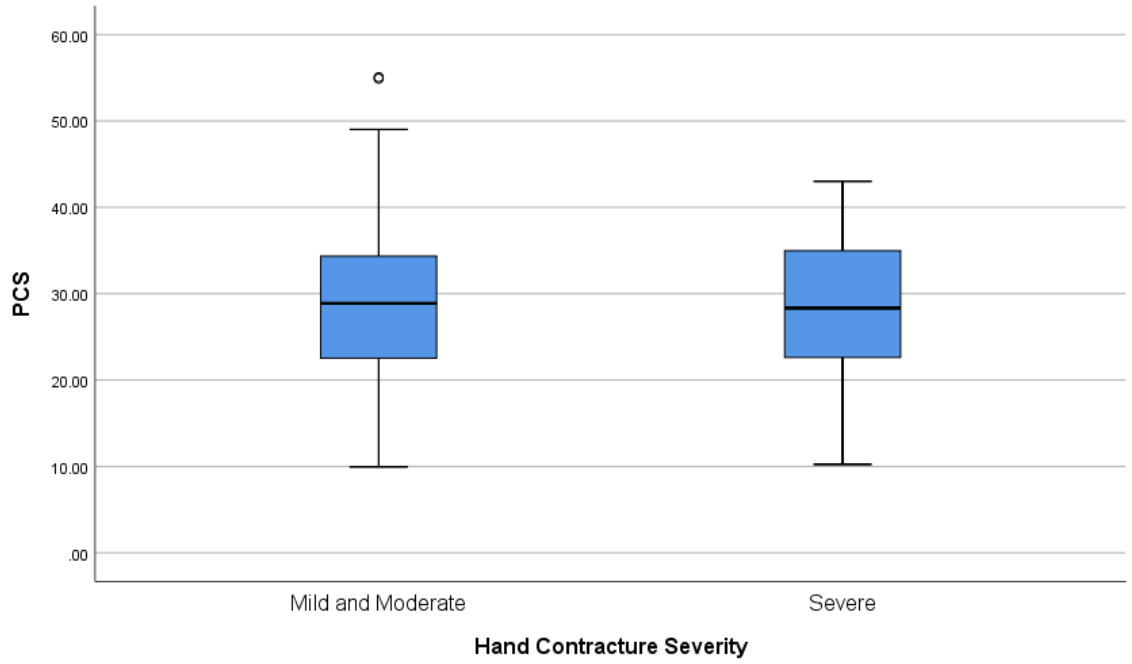


Figure 5: *Box Plot of SF-36 Score Categorized by Contracture Severity (mild and moderate, severe)*



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