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The strength of the evidence for splinting and serial casting as treatment for elbow contractures in burn survivors: An integrative Critical Literature Review

by

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Abstract

Background. Elbow contractures in burn survivors lead to difficulties in their ability to perform meaningful occupations. Interventions focus on improving movement at the elbow while considering social and psychological factors in the individual's environmental context. **Objective**. The purpose of the review was to determine the methodological quality of research evaluating splinting and serial casting to improve elbow contractures and resulting functional limitations. **Methods.** A comprehensive search strategy uncovered 10 research studies. Standardized critical appraisal tools and protocols were used to analyze the research. **Findings.** Although some methodological issues were identified, the findings were positive. Strengths and weaknesses of the research were delineated to support and guide the use of serial casting and splinting. A body of research was found to warrant consideration of social and psychological factors. **Conclusion.** There is preliminary quality evidence to support the use of splinting and serial casting and important considerations for future research.

Key words: contracture, burns, cicatrix, serial casting, splinting, progressive stretch, range of motion, outcome measures, activities of daily living, quality of life.

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CHAPTER 1. INTRODUCTION & OBJECTIVES

1.1 INTRODUCTION

A major complication of burn injury is contractures caused by a tightening or shortening of a body part such as muscle, tendon or the skin and, when the contracture involves a joint, it is defined as an inability to perform full range of motion (ROM) of a joint (Schneider, Holavanahalli, Helm, Goldstein, & Kowalske, 2006). Contractures are caused by damage to the skin and underlying soft tissue, by the contracting forces of wound healing, and by immobilization (Cooney, 2000; Schneider et al., 2006). There is thought to be a higher risk of contractures in burn survivors with larger or deeper burns and in those with burns that cross a joint (Kraemer, Jones, & Deitch, 1988; Schneider et al., 2006).

A common approach to correcting contractures related to burn injuries is the use of orthotic devices such as splints (Daugherty & Collins, 1994; Jordan, Daher & Wasil, 2000; Richard & Ward, 2005). Orthotics is the generic term to describe devices applied to the body to immobilize, stabilize, and prevent or correct deformity (McKee & Rivard, 2004). The rehabilitation of individuals with joint contractures due to a burn injury is complicated by the array of available orthotic interventions and lack of evidence-based guidelines to assist the therapist and burn survivor in making the best treatment choice (Glasgow, Wilton, & Tooth, 2003; Richard et al., 2009; Richard, Miller, Staley, & Johnson, 2000; Richard & Ward, 2005). Treating this type of injury requires specialized skills and knowledge as indicated by the presence of specialized burn centers in both Canada and the United States. The National Burn Repository, located in the United States, provides a report that reviews a combined data set of acute burn admissions (American Burn Association, National Burn Repository 2010). The report states that over a 10 year period 148,419 people were admitted with acute burn injuries to 83 of the 124 specialized burn centers in the United States (American Burn Association, National Burn Repository, 2010). Data for Canadian burn centers is limited; only four out of the 14 specialized burn centers contributed to the National Burn Repository. However, recent national statistics place Alberta, with 448 annual admissions, as the third highest in the country for hospital admissions related to burns (Canadian Institute for Health Information, 2009). The Firefighters Burn Treatment Unit (FFBTU) in Edmonton is one of the three specialized burn centers in Alberta and has the added responsibility of providing good quality burn care to a catchment area beyond the province. The unit

accepts admissions from Alberta north of Red Deer, northern British Columbia, the entire province of Saskatchewan, the Territories and Nunavut.

Incidence rates for elbow contractures have been reported to be as high as 39% in individuals treated for burns in a hospital setting (Huang, 2002). A review of the records of 1005 patients treated at the Shriners Burns Hospital in Galveston, Texas over a 25 year period, found elbows as the joints most commonly affected. Out of 1005 patients with burn injuries: 397 had elbow joint contractures, followed by 283 with knee contractures, 248 with axilla contractures, and 77 with hip contractures. Although contractures related to burn scars may occur in a number of joints, of particular concern is the elbow contracture due to the elbow's high importance and priority during elementary motions, and because restrictions at the elbow results in severe disability (Cooper, Shwedyk, Quanbury, Miller, & Hildebrand, 1993). Use of an orthotic device is one approach utilized by therapists working with burn survivors to reduce contractures (Richard, Staley, Miller, & Warden, 1996).

A preliminary literature search revealed a paucity of evidence-based practice guidelines in the application of splinting and serial casting for individuals with burn injuries. This preliminary search is discussed in more detail under 3.3.2.1. Without guidance from evidence-based guidelines, therapists depend on clinical expertise, background knowledge and creativity to decide which strategy is more effective in reducing contractures that result from scarring (Spence & Ware, 2006). To provide the best quality of care to injured burn survivors, guidelines need to be developed based on an examination of research done in this area that include both quantitative and qualitative features.

Literature review and synthesis has been recognized as important in evaluating the effectiveness of clinical interventions and, in turn, developing evidence-based clinical practice guidelines (Powe, Turner, Maklan, & Ersek, 1994). This integrative Critical Literature Review (CLR), as outlined in the McMaster protocols (Law & MacDermid, 2008), examines the methodological strength of the evidence based on the quality of the research regarding these interventions. This CLR also aims to provide direction for the future creation of evidence-based guidelines. Areas for future research are identified in light of the gaps uncovered. Hereafter the integrative CLR (Law & MacDermid, 2008) will be referred to as the integrative McMaster CLR in recognition of the authors' contribution to the development of the protocols and forms. The authorship will be taken

for granted from the title McMaster CLR and dropped from being included after every reference to the McMaster CLR.

1.2 OBJECTIVES

An integrative McMaster CLR is used to determine the methodological strength and quality of the evidence in the outcome research of splinting and serial casting for individuals with elbow contractures resulting from burn injuries. The research questions addressed in this McMaster CLR are: 1) Is the methodological strength of the evidence such that splinting and serial casting can be considered an effective intervention to improve elbow contractures in burn survivors? 2) Is there sufficient evidence to support the use of one type of orthotic over another? 3) What evidence is there to warrant consideration of mitigating factors that may influence the effectiveness of splinting and serial casting?

The integrative McMaster CLR demonstrates and discusses the evaluation of available evidence regarding the effectiveness of these interventions through a structured examination of the methodological strength and quality of the evidence. Outcomes of interest to occupational therapists are addressed, namely occupational performance (e.g. participation in self-care, productivity and leisure) and the physical and affective occupational performance components.

The next chapter reviews the work that has been done regarding the treatment of elbow contractures resulting from burn injuries, provides information on the condition itself and the mitigating factors that need to be considered when examining this type of intervention.

CHAPTER 2. BACKGROUND LITERATURE REVIEW

In burn rehabilitation textbooks, splinting and serial casting are recommended to reduce elbow contractures that result from contracted burn scar (Daugherty & Carr-Collins, 1994; Malick, 1988; Parent, 1989; Richard & Staley, 1994). At the May 2008 *Consensus Summit: Burn Rehabilitation and Research,* an operational definition for burn scar contracture was proposed and it will be adopted for the purposes of this study as follows: "an impairment caused by replacement of skin with pathologic scar tissue of insufficient extensibility and length resulting in a loss of motion or tissue alignment of an associated joint or anatomic structure" (Richard et al., 2009). Although serial casting has been shown to be an effective method to treat burn scar contractures, the use of splinting is also quite common (Nakamura, 2006; Ricks & Meagher, 1992; Spence & Ware, 2006; Tenenhaus, 2006; Tredget, Scott, & Ghahy, 2006). Serial casting involves the use of a progression of casts (static progression) that apply force to stretch the tissues surrounding the joint. This creates a stress relaxation reaction in the tissues. Tissue relaxes and elongates within the cast which then requires the force to be reapplied in order to obtain further elongation. While serial casting always uses a static progressive approach, splinting has more versatility and can be used for other approaches according to the type of splint. There are three types of splints that are described in the literature related to treating elbow contractures including static splints, static progressive splints and dynamic splints (Doornberg, Ring, & Jupiter, 2006; Lindenhovius & Jupiter, 2007; Michlovitz, Harris, & Watkins, 2004; Richard & Ward, 2005). Static splints are rigid appliances, typically made from a thermoplastic material, applied to the elbow to maintain a position or stretch tissue to within the confines of the splint. Static progressive splints require that the rigid appliance be modified or adjusted to accommodate changes in the position. Dynamic splints allow movement at the joint while applying a force in a specific direction. All three types have a common purpose, which is to increase ROM in a specific joint. It is believed that improving ROM to within functional ranges leads to improved abilities to carry out daily activities (Parent, 1989). This is of interest to occupational therapists as their focus is on the domain of occupation, the groups of activities and tasks of everyday life including self-care, enjoying life, and productivity (Townsend & Polatajko, 2007). Or in other words, as described in *Enabling Occupation* (CAOT, 1997a, p.34), "occupation is everything people do to occupy themselves".

This section will review the context in which elbow contracture treatment occurs as well as a model to guide the reader.

Three groups of activities: self-care, leisure and productivity, are described in the Canadian Model of Occupational Performance and Engagement (CMOP-E) as occupational purposes with occupation being the bridge that connects people with the environment (see Appendix A: CMOP-E). Utilizing this model, an elbow contracture is seen as the physical component that restricts movement and subsequently affects a person's ability to interact with their environment, e.g. reaching, placing or manipulating items in space. In order to enable burn survivors with elbow contractures to perform meaningful occupations, the occupational therapist concentrates on improving movement at the elbow while considering each person's individual environmental context.

The interventions, splinting and serial casting, can be viewed in two different ways. On the one hand, the interventions ultimately work to enable a person to perform an occupation by reducing restrictive contractures. On the other hand, the intervention can be viewed as restricting a person from performing an occupation due to the immobilization of a body part typically used during performance of occupations, the arm in this case. McKee and Rivard (2004) describe this dilemma as similar to the situation regarding prescribed medication, in that each has adverse as well as positive effects. In order to ensure the intervention does indeed have these positive effects, the effectiveness of the intervention needs to be established to provide the burn survivor with accurate information for decisions as to whether the negative effect of immobilization is worth the positive effects. This process of engaging the burn survivor in choosing the intervention is supported by the literature: a client-centred process for the provision of orthoses that enables occupational performance and helps to optimize outcomes (McKee & Rivard, 2004; Townsend & Polatajko, 2007). Orthoses is the general term to describe devices applied to the body to immobilize, stabilize, and prevent or correct deformity (McKee & Rivard, 2004).

Referring to the CMOP-E to illustrate the interaction between person and environment, each individual lives within a unique environmental context in which cultural, institutional, physical and social factors influence decisions (Townsend & Polatajko, 2007). It is for this reason that this review has included these factors as important and influential in the outcome of any treatment regime.

In order to further understand the complexity of the problems associated with treating contractures related to burn injuries, information is presented here on the biomechanical approach to treatment as well as additional factors, personal and environmental factors that may accompany this type of injury.

2.1 BIOMECHANICAL APPROACH

A biomechanical approach is used when treating burn contractures with splinting and serial casting. It is applied in cases where there is a loss of ROM, strength, or endurance due to illness or trauma that affects muscles, joints, skin or other connective tissues.

The biomechanical approach applies laws of physics and engineering concepts to describe movement of various body segments and the forces acting on these body parts (Nordin & Frankel, 1989). Using this approach, static splints, and static progressive splints or casts are utilized to apply low loads of force to stretch the scar tissue. Gradually the tissue relaxes and less force is required to maintain the extended length, a process referred to as stress relaxation. The force is re-established with the subsequent application of the splint or cast through remolding or re-casting (Bennett, Helm, Purdue, & Hunt, 1989; Bonutti, Windau, Ables, & Miller, 1994; Doornberg et al., 2006; Richard & Staley, 1994). In the case of dynamic splinting, the principle of creep is applied. Creep is the continual elongation of tissue over time achieved by using a constant force to stretch the tissue (Richard, Shanesy, & Miller, 1995). Further information on wound healing, contracture, and the biomechanical properties of skin is provided in Appendix B: Properties of Normal Skin and Burn Scar.

Early *in vitro* studies support the biomechanical principles underlying the use of splinting and serial casting through the examination of the composition and structure of hypertrophic scar (HTS) (Dunn, Silver, & Swann, 1985; Kratz, Tollback, & Kratz, 2001). In the study by Dunn et al. (1985), the mechanical behavior of HTS and normal skin was compared. The results revealed a reduced extendibility in HTS and the need for greater strain energy to stretch it. Kratz et al. (2001) studied the effects of applying a static force to stretch human burn scars. When they stretched HTS samples, using a specially designed stretching device and 50 mm of force (low load), the HTS samples elongated. The elongation was accompanied by a decrease in the force required to be applied by the device, thus supporting the use of the serial method of splinting and casting in the presence of scar tissue. It is important for the therapist to understand how normal skin and scar tissue function in order to prevent or reduce scar contractures. Knowledge of tissue biomechanics serves as the basis for evaluating, developing and monitoring the effectiveness of treatment techniques.

2.2 PERSONAL FACTORS

Involving individuals in performing everyday occupations promotes health and well-being; it is therefore essential that therapists look beyond individual performance capacity and analyze the underlying factors that influence a person's engagement in occupations (Townsend & Polatajko, 2007). Townsend and Polatajko (2007) describe the person as one of the key concepts in the CMOP-E model, as a component of a dynamic relationship with occupational performance and engagement. Factors that belong to the construct of person and are thought to influence a person's engagement in occupation include: the burn survivor's motivation to engage in occupation, motivation and readiness to participate in the treatment regime, and personal reactions to the stigma of occupational loss such as eroded self esteem and poor self-image.

In a client-centred approach, the outcome of improved ROM and subsequent ability to perform meaningful occupations has to be important to the burn survivor as well as the therapist. It is therefore essential to consider the factors that may influence a person's motivation to engage in a specific treatment regime. In a study by Cheng and Rogers (1988), changes in occupational role performance after a severe burn were examined; results showed that a return to independence in self-care was the most likely outcome of acute burn rehabilitation. They suggested that people are motivated to achieve functional independence in self-care as a basic activity of daily living (BADL) due to the highly personal, often private self-care tasks and the experience of dependency during the acute stage of recovery from the burn injury (Cheng & Rogers, 1988). Utilizing this reasoning and placing the focus on the immediate return to functional independence, a custom static progressive splint designed to be removed independently by the individual would likely be a better fit than a cast that remains in place for a prolonged period of time.

Decisions about treatment become more complex when considering the fact that although splints and casts restrict ROM, joint contractures in and of themselves limit range and subsequently affect a person's ability to engage in occupations. The functional ROM at the elbow to permit participation in activities of daily living (ADLs), including self care, is considered to be 30° to 130° of flexion-extension with normal being 0° to 145° (Evans, Nandi, Maschke, Hoyen, & Lawton, 2009; Morrey, Askew, & Chao, 1981; Nakamura, 2006). When deciding on the best course of treatment, the short term inconvenience of immobilization may for some patients outweigh the long term gain of improved function. For example, in individuals with small children who do not have

social support to help with parenting activities may not be able to remain immobilized in a cast that limits the functional use of that arm even for a short time. Although the evidence did not support the use of serial casting as more effective than splinting, it may still be the best choice to achieve the required functional ROM based on therapists' clinical judgement considering other mitigating factors discussed here.

The impact of disfiguring injuries on self esteem and body image has begun to be examined (Fauerbach, Heinberg, Lawrence, & Bryant, 2002). Body image dissatisfaction has been known to prolong difficulties in physical functioning independent of injury severity (Fauerbach et al., 2000). To ensure success for any intervention the decision entails a collaborative process involving the burn survivor and consideration of the personal and environmental factors involved, which are important to provide the therapist with a better understanding of why one treatment method would work better for an individual over another.

2.3 ENVIRONMENTAL FACTORS

Using the CMOP-E model to conceptualize the relationship between the environment and occupation, the environment can be seen as a point of analysis to inform an occupational perspective (Townsend & Polatajko, 2007). Environmental factors, both physical and social, influence occupational performance and shape occupational choice. Barriers in the physical environment such as heavy doors can prevent a person with insufficient upper extremity ROM and strength from entering a building. The social environment is complex and multi-layered, to encompass social interactions that are personal and immediate to those of a broader nature such as family or work group relationships. Institutional funding policies are considered a special component of the social environment, "reflecting society's values, ideals and distribution of power and resources" (Townsend & Polatajko, 2007, p.52). Barriers such as lack of social support or financial assistance can prevent a person from participating in an activity that requires physical, social or financial support from others.

Although work has been done to investigate the physiological and biomechanical reactions of body tissue to external forces, clinical observations suggest a need to examine work done in the area of psychosocial influences as well (Dunn et al., 1985; Kratz et al., 2001; Nordin & Frankel, 1989; Richard & Staley, 1994; Tredget et al., 2006). Adequate social and economic supports are factors being considered under this category. The impact of elbow immobilization on an individual's ability to perform activities of

daily living is different when done for a short period of time versus a prolonged period of time and barriers related to social, psychological and economic support may limit choices. The following discussion supports the premise that these factors need to be considered in the decision to use either serial casting or splinting.

The person's economic situation is an environmental factor that may influence decisions. Depending on the healthcare system in place, there are different options to cover the costs associated with splinting and casting. Currently, persons accessing Alberta Health Services must pay for custom or commercial splints, whereas serial casting is provided at no cost. In Canada, there are varying levels of economic support through government programs such as Workers Compensation Board and Non-Insured Health Benefits or through private third-party insurance companies. However, some people do not fall into the categories necessary to access these funds and are personally responsible for the costs. Splints that are custom made by an occupational therapist typically cost the client less than commercial splints (e.g. a custom elbow extension splint at approximately $54.00 versus a commercial elbow extension splint at $888.00) (Capital Health, 2008; Sammons Preston Canada, 2007). The costs associated with the provision of orthotic devices may influence the choice for people with limited incomes or resources and, therefore, need to be considered when deciding on the best treatment possible for the individual. For a visual illustration of the dynamic interactions between persons, their occupations and the environment in which they live, see Appendix A: CMOP-E model.

Another factor to consider is adequate social support to help the burn survivor with self-care or the more physically demanding instrumental activities of daily living (IADLs) such as housework. Choices regarding whether to engage in a splinting or casting regime that prevents independence in engaging in BADLs and IADLs may be limited for the individual without adequate social support. A recent study, by Isaksson, Lexell and Skar (2007), examined the perception of the importance of social support for participation in occupations including BADLs and IADLs after a sudden and major injury. Social support included practical support (instrumental or tangible) and emotional support (esteem building, belonging, moral support). The findings indicated that people required social support to enable self-care and to increase their confidence and motivation to work towards participation in occupation (Isaksson, Lexell, & Skar, 2007). When a person has adequate social support to facilitate engagement in a regime of prolonged immobilization of the elbow, and the individual is motivated to comply with the

inconvenience of this type of treatment; it is reasonable to consider using a treatment method such as serial casting.

Poor social and economic circumstances adversely affect health according to the Theory of Social Determinants of Health, making it important to include these relevant indicators for their possible influence on treatment (World Health Organization, 2003). To gain further understanding regarding the impact of these personal and environmental factors on rehabilitation interventions, studies that examined these factors were set aside during the comprehensive search strategy for discussion purposes.

In light of the need to address questions related to the effectiveness of splinting and serial casting for elbow burn contractures while considering the context of personal and environmental factors; the integrative McMaster CLR was initiated. The following chapter describes the methods used to examine the body of knowledge regarding treatment and personal and environmental factors and to integrate the information in order to provide practical conclusions and recommendations for therapists working with burn survivors.

CHAPTER 3. METHODS

A critical literature review was chosen as the method to determine the methodological strength of evidence in the outcome research for splinting and serial casting, addressing whether these types of orthoses are effective interventions to improve elbow contractures in burn survivors and whether there is sufficient evidence to support the use of one type of orthotic over another. To ensure the employment of quality methods, a systematic, thorough process was established using the McMaster protocols and forms for critical literature reviews and is discussed in more detail below. Although all inclusion/exclusion criteria were not met to warrant inclusion in the critical review process, literature that addressed the personal and environmental factors discussed in the introduction was reserved to provide background and depth, enriching the occupational perspective. The following section describes the practices and techniques that were used to collect process and analyze information using a four step process. The discussion begins with a description of the integrative McMaster CLR and the McMaster critical appraisal tools followed by the four step process.

3.1 THE INTEGRATIVE CRITICAL LITERATURE REVIEW

An integrative McMaster CLR of the evidence related to the therapeutic use of splinting and serial casting for the reduction in elbow contractures, serves to advance knowledge and provide direction in establishing evidence-based practice guidelines related to the treatment of elbow contractures resulting from burn injury. The McMaster CLR forms and guidelines were chosen for their capacity to evaluate and synthesize evidence from a range of quantitative and qualitative study designs; addressing the unique properties of burn care and research in the area of rehabilitation. The end result of the integrative McMaster CLR is an in-depth summary of the methodological strength of the evidence in the domains of relevance, design, methods, results and conclusions as well as an overview of the strength of the evidence.

Several other protocols for completing critical reviews were considered during the development of this proposal. For example, specific procedures are provided by the Cochrane Collaboration for systematic reviews to be included in the well-known Cochrane Database of Systematic Reviews (Green & Higgins, 2008). However, Cochrane reviews focus primarily on studies with a randomized control trial design (Green & Higgins, 2008). The topic under review requires a broader focus than described above. Rehabilitation research differs from most medical research, in the use of multiple

interventions per medical condition and in measures of outcome that have to address the needs of different stakeholders (persons participating in therapy, therapists, and funders) (Katrak, Bialocerkowski, Massy-Westropp, Kumar, & Grimmer, 2004). Recently, the Cochrane Collaboration has recognized the value of evidence from non-randomized trials and qualitative research; nevertheless, this area is still evolving (Reeves, Deeks, Higgins, & Wells, 2008). Another protocol considered, was that used for Critically Appraised Topics (CATs), a tool produced by practitioners and Occupational Therapy students affiliated with the University of Western Sydney, Australia. The result is a shorter and less rigorous version of a critical literature review. However, a more rigorous scientific approach was chosen as it is preeminent for assessing and minimizing bias in research (Stevens, 2001).

The integrative McMaster CLR is a systematic and rigorous scientific approach for amalgamating results from a body of original research studies into a single report that is clinically relevant. A systematic approach is employed to identify the totality of the evidence base, and then retrieve the evidence from which to record, integrate, and summarize the characteristics or results of independent research studies. The McMaster CLR involves standardized critical appraisal tools to evaluate and establish the utility of selected research reports. The tools pose questions on the research methods and risk of bias. The information gleaned through these questions assist the reviewer in determining the validity of the study results and conclusions. This information is also valuable for ascertaining whether the findings are relevant and applicable to clinical practice (Katrak et al., 2004). This type of review not only provides an overview of research done on the topic, but evaluates it as well. The use of the commonly used Jadad scale as a brief assessment tool for rating the quality of primary studies was limited in this review (Bhogal et al. 2005). It was developed to determine the effect of rater blinding on the assessments of quality in randomization, more typical in clinical trial (RCT) reports (Jadad et al., 1996).

To complete the integrative McMaster CLR, the process involved following specific protocols, developed and tested by the McMaster University Occupational Therapy Evidence-based Practice Research Group, for utilizing the critical appraisal tools. These appraisal tools provide analytical evaluations of the quality of the studies selected and are discussed in further detail under 3.2 Critical Appraisal Tools. Validity is indicated by measures of acceptance by the profession, for example the annual research grant offered by the Canadian Occupational Therapy Foundation for critical literature

reviews using the McMaster protocols in the "Outcomes that Matter to Canadians" project. Eight critical reviews have been funded through the Canadian Occupational Therapy Foundation (COTF) project and can be found on the COTF website at http://www.cotfcanada.org/how/critical/. The use of the protocol and forms in published reviews gives the McMaster CLR validity (Reid, Laliberte-Rudman, & Hebert, 2002; Wilkins, Jung, Wishart, Edwards, & Norton, 2003). And, as an indication of their international importance, the forms and guidelines have been translated into Spanish, German, and Portugese (Canadian Occupational Therapy Foundation, 2010). Further information on the critical tools can be found below.

3.2 CRITICAL APPRAISAL TOOLS

The McMaster CLR forms and guidelines reflect the diversity and complex nature of rehabilitation interventions by allowing for multiple research design methods found in both quantitative and qualitative rehabilitation research along with possible biases associated with each design (Law & MacDermid, 2008). The McMaster CLR Form-Qualitative Studies is comprised of eight categories: purpose, literature, design, sampling, data collection, data analysis, overall rigour, and conclusions and implications. The McMaster CLR Form-Quantitative Studies used in this review is comprised of eight categories: purpose, justification (literature), design, sample, outcomes, intervention, results and conclusions with questions to prompt the reviewer.

Both forms are accompanied by guidelines facilitating the application and interpretation of these tools in a standardized manner (See Appendix C: Critical Review Guidelines). These guidelines are written in basic terms with examples and justification to assist the reviewer in the CLR process. Reliability of the form is good. When testing the final forms and guidelines agreement of 75% to 86% between two researchers was achieved (McMaster Occupational Therapy Evidence-based Practice Group, 2008).

3.3 CRITICAL REVIEW PROCESS

Decisions made regarding which studies warrant inclusion and which information from these studies is presented and analyzed, have an effect on the findings of the integrative review. Details of the four step process involved in the integrative McMaster CLR are presented here.

The four steps:

1. Relevant Topic: Establish a clear question focused on a topic relevant and meaningful to occupational therapists.
2. Literature Search: a) Comprehensive Search Strategy; and b) Study Screening and Selection. Consult experts in the field to confirm search strategy. Identify relevant studies by means of a thorough literature search based on inclusion/exclusion criteria.
3. Critical Review of Accepted Articles: Administer a critical review evaluating the quality of each study against specified criteria using quantitative and qualitative review protocols. Complete a descriptive summary of the key elements of the critical review.
4. Integrative Review/Analysis: Complete an evaluative critique and integrative review of the topic synthesizing the results.

This integrative McMaster CLR is reproducible in nature. A record has been provided of the methods used, the data obtained, and the analytic techniques used for synthesis. Further discussion on the individual steps follows and includes information on how the record was kept.

3.3.1 Relevant Topic (Step 1)

The effect of splinting and serial casting interventions for individuals with burn contractures was chosen for its relevance and meaning to occupational therapists. Occupational Therapy's focus is on occupation as the core domain and enablement as the core competency. In practical terms, occupational therapists are interested in enabling people to perform the occupations that foster health and well-being (Townsend & Polatajko, 2007). This integrative McMaster CLR seeks to explore evidence for splinting and serial casting as an intervention that therapists may suggest and apply to burn survivors with the purpose of enabling them to participate in meaningful occupation. For further explanations on how this topic is relevant to occupational therapists refer to Chapter 2. Background Literature Review and Chapter 4. Relevance of Findings.

3.3.2 Comprehensive Search (Step 2)

A comprehensive search consists of the preliminary search, search strategy, study screening and selection. These processes are discussed individually beginning with the

preliminary search. Appendix D contains all the search tables associated with the comprehensive search and will be referred to throughout.

3.3.2.1 Preliminary Search

All evidence-based medicine reviews were searched in Cochrane Database of Systematic Reviews (DSR), American College of Physicians (ACP) Journal Club, Database of Abstracts and Reviews of Effects (DARE), Cochrane Central Registry of Controlled Trials (CCTR), Health Technology Assessment (HTA) and the National Health Service Economic Evaluation Database (NHSEED). The search yielded three reviews that looked at evidence in the area of splinting and serial casting of the elbow, however, none of them included the burn population and focused on orthopedic injuries rather than contractures related to skin abnormalities (Abraham, Handall, & Khan, 2008; Daugherty & Carr-Collins, 1994; Kratz et al., 2001; NHS Centre for Reviews and Dissemination, 2008a; NHS Centre for Reviews and Dissemination, 2008b).

A search was also done to find any associated evidence-based guidelines. The dearth of evidence-based practice guidelines in the application of splinting and serial casting for individuals with burn injuries was made apparent through a perusal of websites. Seven websites that publish guidelines were searched in addition to two websites specializing in burn care and one website specializing in evidence-based occupational therapy (see Table D1 for further details regarding these websites). No guidelines for splinting and serial casting elbow contractures in burn survivors were found.

3.3.2.2 Comprehensive Search Strategy

The search strategy for the integrative McMaster CLR included both electronic and hand searching . Keywords and subject headings were selected from the foundation literature in the area. In addition, MeSH-based search terms describing the concepts of interest were employed to obtain an optimal number of articles from the electronic databases (see Table D2 for search terms, headings and keywords). A search record was kept.

The search encompassed primary sources of information to inaugurate authenticity and proximity to the topic using the Ovid interface and EBSCO host to search the databases Medline, EMBASE, CINAHL and PsycINFO. Databases containing secondary sources of information, such as EBMR, OTSeeker, PEDro, RehabDATA,

OTDBase and CIRRIE were also searched to identify the evaluative work already done on this topic. Because of the anticipated difficulty in obtaining sufficient information through peer-reviewed journals and to avoid publication bias, grey literature was also included as a search source. This entailed a hand search of the previous five years of the annual American Burn Association (ABA) conference proceedings and the regional burn meetings listed on the ABA website at http://www.ameriburn.org, and the Canadian Interest Group annual meetings In addition, the following databases were searched: Online Computer Library Center (OCLC) Papers First, Conference Papers Index, OCLC Proceedings First, Open System for Information on Grey Literature in Europe (SIGLE), OCLC, Occupational Therapy Critically Appraised Topics (OTCAT), Scopus, Web of Science and Proquest Dissertations and Theses. Reference lists of articles identified in the computer search were examined and scholars recognized for their work on the topic of interest were contacted to assist in locating studies that may have been completed but not submitted for publication or are still in process (see Appendix E: Consultations).

The following experts in the field of burn treatment were consulted during the proposal stage to ensure thoroughness and their recommendations were incorporated into the study: Dr. Bernadette Nedelec, Associate Professor at McGill University in Montreal, Quebec who is an occupational therapist and accomplished researcher in the area of burns and, Lisa Forbes-Duchart, Clinical Specialist in Burn Care at the Winnipeg Health Sciences Centre in Winnipeg, Manitoba, an occupational therapist who recently participated in an international group summit looking at burn rehabilitation and research. The researcher continued to consult with the librarian and research nurse to assist with efficiency in the search (see Appendix E: Consultations).

To minimize the chance of omitting relevant studies, Heather Shankowsky, Burn Research Nurse at the University of Alberta FFBTU, and Linda Seale, Librarian at the University of Alberta were consulted to review the terminology. (See Appendix E: Consultations). The changes that were recommended were incorporated into Table D2.

Because of the broad nature of the inquiry into the effectiveness of splinting and serial casting and efforts to include the environmental and social factors, it was necessary to combine the search terms in various combinations. This approach prevented excluding articles that may have addressed some but not all the factors at once. A web-based citation management system, RefWorks, was utilized to track bibliographic citations and articles identified during the search (*RefWorks.*2008). A summary of the search was tabulated to provide an overview of the search. As well, records of each electronic

database search and hand search through grey literature was tabulated to provide a method to reproduce it (see Table D3 to D7).

3.3.2.3 Study Screening and Selection

To select articles suitable for inclusion in the integrative McMaster CLR, articles underwent a layered screening process, involving titles, then abstracts, then full articles. To begin the selection process, studies were picked up by the identification of key words and terms in the article titles through the search strategy using terms and key words. Abstracts under these titles were then perused for inclusion/exclusion criteria found in Table D8: Inclusion/Exclusion Criteria.

To identify any additional articles that merited consideration, titles in reference lists of those articles that met the inclusion/exclusion criteria were also checked and abstracts were obtained if required for more details. When the entire inclusion/exclusion criteria were applied to the studies, those that addressed environmental or psychosocial factors and general rehabilitation intervention were eliminated due to the requirement that the study specifically address splinting and serial casting interventions. Although not retained in the dataset for critical review, these studies were important for contextual background. Studies that addressed these factors as they related to rehabilitation in general were set aside in order to inform the discussion section (See Table D9).

Finally, those studies that met all the criteria underwent further screening to determine relevancy for inclusion according to the McMaster protocols (Law & MacDermid, 2008) and were tabulated in Table D10: Accepted Studies. These accepted relevant studies were selected to undergo the next step, the individual critical review of accepted articles using the McMaster critical appraisal tools. Appendix F contains a diagrammatic flow chart of the decision process from search to inclusion (see F1).

3.3.3 Critical Review of Accepted Articles (Step 3)

The third step in this integrative process involved an evaluation of the methodological quality of the evidence through a critical appraisal of each relevant study to form the basis of the integrative McMaster CLR. Each article chosen for inclusion in the review was evaluated independently by the researcher using pre-determined criteria established in the protocols and standard data extraction forms for critically reviewing research articles developed and tested by the McMaster University Occupational Therapy Evidence-based Practice Research Group (McMaster Occupational Therapy Evidence-

based Practice Group, 2008). Under the key element - outcomes, an additional tool, the CMOP-E model, was used to categorize outcome indicators found in the selected studies and to determine their relevance to occupational therapy (see Appendix A: CMOP-E model).

Parallel items evaluated in quantitative and qualitative studies include: study purpose, justification, design, sampling methods, and conclusions. In qualitative studies, items that undergo further consideration are clarity and procedural rigour of data collection, analytical rigour in analysis methods, and theoretical connections of the phenomenon under study. In quantitative studies items that undergo further consideration are outcome measures, characteristics of the intervention, co-interventions, appropriate analysis and results of the studies. Once the final selection of the included articles was made, all items were addressed individually on the McMaster CLR forms following the guidelines that accompany the forms (see Appendix C: Critical Review Guidelines and Appendix G: Completed Critical Review Forms).

To ensure inter-rater reliability and prevent bias, a second reviewer, was employed to evaluate each individual research study using the identical data extraction forms and protocols. The second reviewer was an occupational therapist experienced in using the McMaster forms and protocols. Her background as an occupational therapist was important in ensuring the articles were relevant to occupational therapy. Dr. Cary Brown, Associate Professor at the University of Alberta, was consulted to mediate on the responses that were different between the two reviewers and a consensus was reached. Dr. Brown, as expert in the field of critical literature reviews, also performed an audit of the completed audit forms to ensure validity.

Summary tables provide tabulated information to facilitate reporting and discussing the findings from the McMaster CLR and are found in Appendix H. The first table provides a tabulated descriptive overview of the key elements to accompany the narrative description (see Table H11). The description includes the following: the purpose, design and methods of the study; sample size and participant characteristics; interventions and co-interventions; health indicators; outcomes and tool selection; and the reported results or findings. Additional tables to facilitate describing the reported findings and health indicator findings were also created (see Table H12 and Table H13). Whereas the descriptive information provides an overview of the contents of the individual critical reviews, the analysis completed in step four provides an evaluative critique in the form of an in-depth assessment of the quality of the research information

gathered. It is the evaluative critique that validates the judgments on the best course of action for treating contractures related to burn injuries and for further research requirements.

3.3.4 Analysis/Evaluative Critique (Step 4)

The fourth step in the process provided a critical analysis of the quality of the research methods discovered by means of an evaluative critique. The quality of the evidence from clinical studies determines the confidence that practitioners can place in the evidence and makes the critical evaluation of the evidence an essential aspect of evidence based practice (Law & MacDermid, 2008). The critique included in this integrative CLR consists of a review of the following elements of methodological and research design quality: the clarity and justification of study purpose, design, sampling, intervention, results and conclusions. The results of the evaluative critique are provided in narrative and tabulated form to provide the reader with an overview of the key elements. Table 14: Evidence Table shows the results of the evaluative critique. An additional table was created to facilitate the reporting the various biases found in the studies (see Table H15). This analysis of the methodological quality of the research studies is paramount in determining whether the findings provide sufficient evidence to support the effectiveness of splinting and serial casting or offer alternatives that will improve patient care (Portney & Watkins, 2000). Relevance of the outcomes found in the studies was examined using the CMOP-E model as a framework. The results of this analysis regarding relevance of outcomes were tabulated in Table H16 and reported in Chapter 4: Findings.

3.4 Methods Summary

The four step process outlined above produces an evaluative critique of selected articles on the topic of splinting and serial casting as treatment for elbow contractures in burn survivors utilizing the McMaster CLR forms and guidelines and knowledge support from experts in the field and literature on research methods and evaluating research

The results of the evaluative critique are provided in the following chapter followed by a discussion and conclusions resulting in an in-depth summary of the methodological strength of the evidence in the domains of relevance, design, methods, results and conclusions in the form of an integrative McMaster CLR

CHAPTER 4. RESULTS

Timelines are provided to establish the parameters of the research results and to guide future efforts in literature reviews. Preliminary work related to the search was started in August 2009; however the search for articles began in earnest on January 13, 2010 and was completed on March 25, 2010.

The following section provides a report of the results of the comprehensive search, a descriptive overview of the individual critical appraisals and details the results of the evaluative critique. An overview of the comprehensive search is provided in narrative form supported by tabulated information found in Table D4. Following the comprehensive search results, a brief descriptive overview of all the individual studies is provided. Utilizing the results from the search, and the individual critical appraisals of the studies, an evaluative critique is provided for an evaluation of the scientific merit of the accepted studies.

4.1 COMPREHENSIVE SEARCH RESULTS

In total, 20 electronic databases were searched and hand searches were conducted through reference lists, conference proceedings and professional journals (see Table D3). The flow from 8680 articles to the final 10 is shown in Figure F1: Decision Tree.

The search strategy included systematic searching through ten databases that contained peer reviewed articles. Repeat articles were excluded during the initial screening. Of the 201 articles found during the primary screening of the database abstracts, further screening revealed that nine met the *a priori* inclusion/exclusion criteria and were relevant to the topic. Medline was the largest database, and the first one searched. It provided eight articles while the database EMBASE provided an additional article relevant to the integrative McMaster CLR. The last accepted article was retrieved from Scopus. Refer to Tables D4 to D6 for details regarding the search terms, combinations and results related to these database searches.

Another 10 databases that included grey literature were also searched resulting in an additional 63 articles that required further screening. Of the 63 articles, one article that was retrieved from Scopus met the necessary criteria, bringing the total number of articles to 10 for inclusion in the integrative McMaster CLR. Hand searches led to 78 additional articles for further screening. During the screening process in the grey literature, it was necessary to contact three presentation authors for further details to determine whether their presentations were outcome studies that met the criteria. As well,

one thesis was examined in total before the final decision was made to exclude it. The decision to exclude it was based on the fact that it did not meet the criteria of an outcome study and included neurological disorders. See Table D7 for details on search terms, combinations and results related to search through the grey literature databases Conference Papers Index (CPI) and Scopus.

As a result of maintaining a broad approach, 13 studies that looked at personal and environmental factors were found during the comprehensive search process. This entailed reviewing all 289 articles in full to determine if the outcomes included any of these factors and if they were related to the specific intervention under review. The 13 studies discovered addressed factors that were relevant to the topic but they did not meet all the criteria to be included in the critical review; they examined the relationships between personal or environmental factors and rehabilitation intervention and outcomes in more general terms (e.g. physical rehabilitation, rehabilitation programs and rehabilitation therapy) and were not specific to splinting or serial casting. The findings from these studies provide an important theoretical adjunct for the conclusions drawn from the integrative McMaster CLR and will be discussed in further detail in section 4.4. A list of these 13 studies and their general findings can be found in Table D9: Mitigating Factors Studies.

In summary, there were 289 articles selected by their abstracts. In an effort to include the mitigating factors described above, it was necessary to read entire articles to determine if the studies were relevant. Because of the propensity of researchers to describe rehabilitation interventions in general terms, closer scrutiny was required to ascertain what the exact nature of outcomes were. After reading the full article to determine whether they met with inclusion/exclusion criteria, the majority of these articles were eliminated leaving 10 studies that met all the criteria. The accepted studies are listed in Table D10 and are described in the descriptive overview that follows.

4.2 DESCRIPTIVE OVERVIEW OF ACCEPTED ARTICLES

A descriptive overview of the studies is provided to familiarize the reader with the selected studies. The completed Critical Appraisal Forms for each individual study are found in Appendix G: Completed Critical Review Forms.

Every effort has been made to refer to the individual(s) involved in these studies as burn survivors in order to represent their ability to engage in and influence their intervention choices. However, the author is obligated to remain consistent with the

specific study(s) under discussion by using whichever term the study uses to describe it, e.g. patient.

The following information provides a descriptive overview of the key characteristics of the selected studies found during the critical review. To begin to familiarize the reader with the studies, a description of the purpose of each study is outlined. Following that, a brief descriptive overview of the accepted articles according to their key elements is provided including the study designs; sample size, participant characteristics; interventions; outcomes and the results or findings. A descriptive summary of the quantitative studies according to the key elements is also presented in tabulated form (see Table H11).

4.2.1 Description of Study Purpose

The study purpose of each of the 10 selected studies, focused on the treatment of contractures. Beginning with the earliest study, Larson et al. (1971) looked at special techniques that could alter and control the sequelae of hypertrophic scars and contractures in thermal injuries. The remaining study purposes are discussed according to the type of intervention, splinting or serial casting.

Splinting interventions were the focus of five of these studies. Huang, Blackwell and Lewis (1978) reviewed 10 years of medical records to evaluate the efficacy of splints and pressure on burn scars across major body joints. Then Richard (1986) used a case study to describe the success of a dynamic splint in the treatment of an elbow contracture. Nine years later, he led a research team in a study to demonstrate the superiority of the dynamic splint over a static splint to correct progressive loss of elbow ROM (Richard et al., 1995). Two of the 10 studies investigated the effectiveness related to specific splinting protocols (Bonutti et al., 1994; Glasgow et al., 2003) while Richard et al. (2000) compared a multimodal treatment approach (no splints) with a progressive treatment approach (included serial casting and/or splints).

Serial casting was the focus of three of the ten included studies. Bennett et al. (1989) did a study to assess the effectiveness of serial casting as an intervention for burn contractures that did not respond to traditional forms of treatment such as splinting. Shortly thereafter, Ridgway, Daugherty and Warden (1991) used a case study to demonstrate the effectiveness of serial casting to correct burn contractures in the pediatric population when compliance is unreliable. Four years later Johnson and Silverberg (1995) undertook a study to demonstrate the effectiveness of serial casting in plantar

flexion contractures in the acute phase of a burn injury when there may still be open wounds. The next section briefly describes the remaining key elements included in the integrative McMaster CLR.

4.2.2 Descriptive Overview of Remaining Key Elements of Quantitative Studies

The designs, sample size, characteristics, interventions, outcomes and results found in the included studies are described in general terms in the descriptive overview. Refer to Table H11 for a breakdown of the key elements according to the individual studies. Further details on the findings and the quality found in these key elements will be discussed under the evaluative critique findings.

The 10 study designs were varied and included a number of study designs including case studies, before and after-designs, case series, single case design, case control design, and the sequential clinical trial.

In regards to sample size, the studies again varied widely. Four of the 10 studies used a single subject; three of the 10 included between five and twenty five subjects; and three included more than twenty-five subjects in their study.

Sex and age characteristics of the subjects were described in all but 10 of the studies (Huang et al., 1978). The characteristics described by the remaining nine studies are described as follows. Differences exist between the studies on both these characteristics. Females were looked at exclusively in two of the four case studies (Johnson & Silverberg, 1995; Richard et al., 1995); and males were looked at in the other two case studies (Richard, 1986; Ridgway et al., 1991). The remaining five of the nine studies that reported sample characteristics included both males and females (Bennett et al., 1989; Bonutti et al., 1994; Glasgow et al., 2003; Larson et al., 1971; Richard et al., 2000). With regards to age characteristics: five out of nine studies looked at paediatric populations (Bonutti et al., 1994; Johnson & Silverberg, 1995; Larson et al., 1971; Richard et al., 1995; Ridgway et al., 1991), three at adults (Glasgow et al., 2003; Richard et al., 1995; Richard et al., 2000; Richard, 1986), and two included all ages. Further discussion on the implications of these differences will follow in the findings under the evaluative critique.

Interventions in all 10 studies included splinting and/or serial casting. Of the 10 studies, five involved the use of both creep and stress relaxation principles (Glasgow et al., 2003; Larson et al., 1971; Richard, 1986; Richard et al., 1995; Richard et al., 2000). Three of the ten studies utilized only creep principles (Bennett et al. 1989; Johnson &

Silverberg, 1995; Ridgway et al. 1991), while two of the ten studies focused on intervention that only utilized stress relaxation principles.

Outcome indicators in the treatment of elbow contractures from burn injuries were established prior to beginning this study. In anticipation of the use of multiple outcome measures, the relevant outcomes were prioritized as primary and secondary outcomes. Designated primary outcomes include: the performance component of physical functions or structures (ROM, neuromusculo-skeletal and movement related functions), as well as the ability to carry out activities of daily living. Secondary outcomes include: integumentary changes, and burn survivor satisfaction. For the purposes of this study, functional activities are defined as (the ability to carry out) activities of daily living such as self-care, productivity and leisure. Patient satisfaction is defined as the degree to which the individual regards the health care service or product or the manner in which it is delivered by the provider as useful, effective, or beneficial in keeping with the MeSH definition introduced in 1992 (*Patient Satisfaction - MeSH Result*). The results of the studies are categorized under primary and secondary outcomes and will be discussed using this categorization later under the Quality of Results section.

Briefly, the authors in all 10 studies reported results that indicated that the use of splinting or serial casting increased ROM and subsequently improved or resolved contractures. Independence in ambulation was reported in two of the 10 studies (Johnson & Silverberg, 1995; Ridgway et al., 1991), and patient satisfaction was discussed as positive in the Bonutti (1994) study. In the Larson et al. (1971) study, the effect of traction or tension on collagen fibre was examined using tissue biopsies. Findings showed a change in collagen patterns from an irregular pattern with nodule formation to a pattern of parallel alignment with two weeks of traction.

Ostensibly, the findings described above appear to provide a strong argument in favour of splinting and serial casting for the treatment of contractures in burn survivors. However, to determine the methodological strength of this evidence, the quality and subsequent significance of the findings need to be considered and will be discussed in detail in the following section under results of the evaluative critique.

4.3 RESULTS OF EVALUATIVE CRITIQUE OF ACCEPTED ARTICLES

To evaluate the scientific merit of the accepted articles and consequently their value in an integrated review, the quality of the research was analyzed and presented as an evaluative critique following the key elements categorized according to the McMaster

CLR critical appraisal forms. A narrative report on the evaluative critique addressing each of the key elements of purpose, design, sampling, intervention, results and conclusions is presented below. Refer to Table H14: Evidence Table for an overview of the quality of the selected studies.

4.3.1 Quality of study purpose:

A clear statement of purpose helps determine if the study is relevant to the reader while a relevant background literature review is required to justify the need for a particular study, thus supporting its purpose. Both are considered factors that contribute to the quality of a quantitative research article (Law & McDermid, 2008). First, the findings related to the clarity of purpose will be reported then the adequacy of the background literature reviews.

4.3.1.1 Clarity of Purpose: The purpose was stated clearly in all the studies except the oldest study, that of Larson et al. (1971). In the Larson et al. study (1971), assumptions are required to determine the primary purpose of the study. During the earlier years, when skeletal traction was used, a group of physicians lead by Dr. D.L. Larson observed that the sequelae of hypertrophic scars and contractures in thermal injuries could be altered and controlled with special techniques. Skeletal traction is an invasive procedure in which pins or wires are surgically installed into the bone to provide an anchor for traction or pulling. The purpose of the Larson et al. (1971) study was to describe the dynamic factors of freshly healed burn wounds in relation to interventions and help establish a base upon which future studies could build their arguments. In the first part of the study current techniques for decreasing scar formation were reviewed, and contractures plus five successful case studies are also reported. However, the reader has to search the entire article to find a statement of purpose, which is found later in the article within the discussion section. Because this was a relatively new area of research at the time, it appears that the nature of the research was more that of hypothesis-generating and may explain the lack of a clear priori hypothesis.

Overall, a focus on the treatment of contractures was reflected in the purpose of each of the 10 selected studies with a gradual progression from exploring, to describing, to evaluating the effect of splinting and serial casting. Exploration is seen in the two early studies by Larson et al. (1971) and Huang et al. (1978). In 1978, Huang and his group of physicians noticed that the use of splints in their facility had decreased the

incidence of contractures in burns and so conducted a study to evaluate the efficacy of splints and pressure on burn scars across major joints by exploring the incidence of contractures compared to splint use. Two of the 10 studies went on to describe the success of specific types of splints in the Richard (1986) study and the Richard et al. (1995) study. Richard then led a research study that attempted to establish the effectiveness of splinting over other approaches in the Richard et al. (2000) study. These three studies illustrate the progression in purpose from that of simply demonstrating the effectiveness of an intervention to that of establishing its place in a hierarchy of interventions. When the use of serial casting gained attention as an alternative to splinting, we find one study, the Bennett et al. (1989) study with the purpose of evaluating the effectiveness of serial casting followed by two studies that demonstrated the success of serial casting, the Ridgway et al. (1991) study and the Johnson & Silverberg (1995) study. Two of the 10 studies looked beyond the overall effectiveness of the splinting intervention and investigated the effectiveness related to specific splinting protocols (Bonutti et al., 1994; Glasgow et al., 2003).

4.3.1.2. Relevant Literature Review: Six out of the 10 studies that included previous work done in the area of soft tissue contractures and/or sustained stretch interventions using splints or casts were considered to have a relevant literature review (Bonutti et al., 1994; Glasgow et al., 2003; Huang et al., 1978; Johnson & Silverberg, 1995; Larson et al., 1971; Richard et al., 2000). The foundation of a relevant background literature review clarifies the research rationale and provides the basis for interpreting the results (Portney & Watkins, 2000). The research rationale common to all the studies accepted for this integrative McMaster CLR is based on the need to address the underlying cause and suggested mechanisms for resolving contractures. Relevant theoretical background material is required to help the reader understand why the intervention should be studied and helps establish what work has already been done in the area. Bennett et al. (1989) stated the justification for their study was in the need to explore options for patients who are non-compliant as they have greater incidence of refractory contractures. Missing is the literature to support this claim as well as a reference to the exploratory work done by Larson et al. (1971) and Huang et al.(1978) on the relationship between stretch and contractures. Another study that missed acknowledging these earlier works included the Richard (1986) case study on the use of a dynamic splint to correct an elbow contracture, despite his reference to an older article from 1966 that discussed the rationale and clinical

management of contractures. As mentioned above, the research rationale provides the basis for interpreting the results, without a strong rationale, the results are more difficult to interpret (Portney & Watkins, 2000). As an example, the Richard et al. (1995) study referred to a review of splinting materials and a study on the use of splints, however, their conclusions that the major reason for the results was based on biomechanical principle of "creep" without adequate background information, made it more difficult for the reader to see the results in that same light. The last study to be mentioned under the background literature review critique is the Ridgway et al. (1991) study. Numerous references were included in their background review including the Larson et al. (1971) study, however, an important and relevant study, the Bennett et al. (1989) study which studied the same intervention of serial casting in burn patients, was not included despite being published by then.

Richard et al. (2000) was a good example of a thorough background literature review as they included all published studies describing work done in the area up to that time and included the results of several literature reviews.

The next section addresses the quality of the designs and methods of the studies included in the integrative McMaster CLR.

4.3.2 Quality of Design

There are numerous ways to classify and describe research designs, with the terms often defined differently by different authors (Brink, van der Walt & van Rensburg, 2006). Important differences are revealed by design types and a brief description of the commonly accepted differences is presented here to guide the reader in interpreting the results of the evaluative critique of designs.

Distinguishing between experimental and non-experimental designs is straightforward with the difference being that experimental designs manipulate the independent or causal variable and non-experimental designs do not. The quasi-experimental design is considered a type of experimental design that includes manipulation of the variable(s) but does not have all the requirements of a true experimental design such as randomization or control groups (Brink et al., 2006). Three of the ten studies were quasi-experimental in nature (Bennett et al., 1989; Glasgow et al, 2003; Richard et al. 1995).

Non-experimental designs include descriptive and correlational designs. Portney and Watkins (2000) describe descriptive and exploratory approaches as observational in

nature; data is collected as it naturally exists and the manipulation of variables does not take place. Descriptive designs merely describe a phenomenon whereas exploratory designs attempt to determine and describe the relationships that exist between the variables. The following studies used a descriptive approach: Bonutti et al., 1994: Johnson & Silverberg, 1995: Larson et al. 1971; Richard, 1986; and Ridgway et al. 1991. The remaining two are considered exploratory according to the above definitions (Huang et al. 1978; Richard et al., 2000).

The McMaster guidelines provided descriptions of seven of the most common types of designs found in rehabilitation research (see Appendix C). The types of designs found in the accepted studies matched those found in the guidelines with the exception of the case series and the sequential clinical trial which were matched to the closest design according to their methodological approach.

4.3.2.1. Descriptive Designs: The descriptive case study is considered the least rigorous design due to its inherent lack of control and limited ability to be generalized. Effects of multiple interventions, environmental factors and personal characteristics make it weak in internal validity (Portney & Watkins, 2000). Responses of one individual may bear little resemblance to those of others in similar circumstances limiting the ability to generalize the single case to the larger population. Nevertheless, the case study is designed to investigate, analyze and understand those factors important to the care and outcome of the subject's problem and may describe the applicability of new devices (Portney & Watkins, 2000). This reasoning is reflected in four of the 10 studies that used a case study design (Johnson & Silverberg, 1995; Larson et al., 1971; Richard, 1986; Ridgway et al., 1991). All four case study designs provided descriptive information about the techniques used to correct burn contractures.

The other descriptive design is the before-and-after case series by Bonutti et al. (1994). Case series are considered to have a negligible role in assessing treatment efficacy and are more appropriate for generating hypotheses for future research or for assessing treatment outcomes such as safety (Kooistra, Dijkman, Einhorn & Bhandari, 2009). Although this design is appropriate for evaluating factors associated with treatment it is not an appropriate design to evaluate effectiveness. At this point, the design is not deemed as inappropriate because the authors stated the purpose was to evaluate the new orthotic in light of other treatments that cause possible skin tearing and pain.

Portney and Watkins (2000) provide an explanation for the progression in study designs noted during this review. They state that as more case studies are reported, a form of "Case Law" develops, whereby empirical findings are considered reasonable within the realm of accepted knowledge and professional experience. As more documented cases are brought forward, a conceptual framework forms which provides a basis for categorizing patients and for generating hypotheses that can be tested using exploratory or experimental methods. It is possible to view this conceptual framework as the basis for the exploratory and prospective quasi-experimental study designs that followed. Refer to Figure F2. Conceptual Framework to view diagram depicting visual representation of this conceptual framework used in case law.

4.3.2.2. Exploratory Designs: The two studies that used exploratory approaches were retrospective and employed a case control design and a longitudinal cohort design. Huang et al. (1978) used a case control design considered to identify factors which occur more or less often in the group of cases (with splints/pressure) versus the comparison group (without splints/pressure) with the aim to investigate any cause and effect (Bowling, 2007). Richard et al. (2000) used a longitudinal cohort design, considered useful for generating hypothesis, economical in time and resources and pave the way for future trials (Bowling, 2007. It also allows exploration of extraneous variables such as motivation in this case. Unfortunately, insufficient information was obtained and therefore not analyzed. One of the disadvantages of a retrospective design is the problem of incomplete or inadequate data (Portney & Watkins, 2000).

4.3.2.3 Quasi-Experimental Designs: The three quasi-experimental studies were prospective designs: the Glasgow et al. (2003) study, the Bennett et al. (1989) study and the Richard et al. (1995) study. Prospective studies are considered more reliable because of the potential for greater control of data collection methods (Portney & Watkins, 2000). Despite this fact, studies that use retrospective data are also considered an important source of information as sometimes this is the only way the question can be answered (Portney & Watkins, 2000). For example, the study by Huang et al. (1978) was able to recruit 625 cases using retrospective chart reviews to evaluate the efficiency of splints on burn scars across major joints. To conduct a prospective study with a similar magnitude of subjects would take an unreasonable amount of time. In addition to the time factor, ethical issues would arise concerning withholding treatment or providing treatment that

has been found to be ineffective. The sequential clinical trial design used in the Glasgow et al. (2003) study appears to offer a solution to this dilemma by reducing the number of subjects needed without losing statistical power. As soon as enough data is collected, the trial is stopped and therefore a trial that is showing no benefit or harmful effects can be quickly terminated (Tooth, 1999).

Levels of evidence are based on the type of research design. Hierarchies of levels have been used that proceed down through quasi-experimental designs, observational study designs, and descriptive designs. Traditionally, designs that are located at the higher levels of a hierarchy were considered better sources of evidence than those located near the bottom. This type of linear thinking is falling from favour as researchers recognize that the rigour of a study is what makes it sound evidence as opposed to its design and therefore level (Law & MacDermid, 2008).

As part of the individual critical appraisal under the key element of design, the evaluator was asked to specify any biases operating and the direction of the influence on the results. How successfully the study under review avoided bias and confounding factors that resulted from flaws in research design and methods helps determine the validity of the results and will be discussed in more detail within the evaluative critique of the results of the study. The next section addresses the quality of the sampling methods of the studies included in the integrative McMaster CLR.

4.3.3 Quality of Sampling Methods

To evaluate the adequacy of the samples in the accepted research studies, several aspects of the sampling procedure were systematically evaluated according to the McMaster guidelines. The McMaster guidelines require that the sample be detailed enough to have a clear picture of who was involved including a description of those characteristics that are important to the topic of interest. This guides the reviewer in forming conclusions regarding the relevancy and applicability of the individual research study's results (see Appendix C). All 10 of the included studies provided detailed descriptions of the sample, with the exception of the Huang et al. (1978) study and the Larson et al. (1971) study (see Table H14).

4.3.3.1 Representative Samples: Finding a sample to represent the entire population of burn survivors with elbow contractures is very difficult. Instead representative samples are selected from an accessible population, which tend to be found in large hospitals

(Chatburn, 2010). This selection of a sample from targeted accessible populations applies to rehabilitation research. Although the selected sample may not represent all burn survivors with elbow contractures, it does represent those burn survivors with elbow contractures that present in our hospitals typically requiring rehabilitation. The accessible population should therefore be described in detail by the study authors as this population determines the target population. In the Huang et al. (1978) study, the sample was a large 625 subject sample and was described as burn patients with burns involving a major joint that were treated at 2 hospitals in Texas over a ten year period. Two important characteristics are mentioned here, the diagnosis of burns and the location of the burn over a joint, however, no other characteristics were reported. Because the study was an early study, before the discovery that various characteristics have an impact on contractures in burn survivors, the individual characteristics did not play as important a role as it does today.

In a case study design, a comprehensive background of the subject's background allows the thorough analysis of a situation and may lead to the discovery of relationships that were not obvious before (Portney & Watkins, 2000). In the Larson et al. (1971) study, five cases of pediatric patients were selected to demonstrate the properties of burn wounds by examining the way the wounds responded to changes in stress and external pressure. Although providing further information on the characteristics of the individual subjects may have provided an opportunity to discover new relationships, again we see the temporal influence reflected in the primary purpose of the study. At that time examining the properties of burn wounds needed to be established before moving on to the possible influence of patient characteristics.

Characteristics of burn survivors that are of interest today include sex, age, treatment setting, mechanism of injury, extent and location of injury. Information on these particular characteristics was provided to some degree in all the studies. For comparison to the larger population, data on these targeted characteristics is available from the National Burn Repository (National Burn Repository Advisory Committee, 2010).

4.3.3.2 Justification: Justification of the sample size is often based on the population available for study according to the McMaster Critical Review Form guidelines. How the authors determined the sample size, or how that particular number was chosen was not discussed in any of the studies except the Glasgow et al. (2003) study. The Glasgow

(2003) study employed a randomized sequential clinical trial design to maintain statistical power in spite of reducing the number of subjects required for a clinical trial. Subjects were randomly assigned to one of two splint groups using a random permuted block design. This is a method of counterbalancing recruitment to ensure equal numbers of subjects are randomly allocated to each group (Whitehead & Marek, 1985). This is considered random allocation and not random sampling. The other study that was considered to have a justified sample size was the Huang et al. (1978) study. Although the authors did not comment on the sample size, a large sample size is often required for case-control studies (Bowling, 2007).

When using probability or random sampling in quantitative sampling, the researcher can calculate the exact number of subjects needed according to how much sampling error is acceptable (Brink et al., 2006). However, all the included studies in this review used non-probability sampling, considered a non-random method for selecting a sample from the accessible population in which sampling error cannot be calculated. Because all the elements of the population do not have an equal chance of being selected we cannot readily assume that the sample represents the target population. This non-probability technique is used more often in clinical research and out of necessity (Portney & Watkins, 2000).

In eight of the 10 studies, there was no indication of whether an ethical process was followed (Bennett et al., 1989; Bonutti et al., 1994; Huang et al., 1978; Larson et al., 1971; Richard et al., 1995; Richard et al., 2000; Richard, 1986; Ridgway et al., 1991). Physician consent was mentioned in the Johnson and Silverberg (1995) study. The Glasgow et al. (2003) study did indicate that an ethics procedure was followed and written informed consent was obtained before random allocation to groups. Of interest is the Larson (1971) study in which the parents of a pediatric burn survivor are described as "mentally retarded" (page 808); a situation which in today's standards, would warrant special considerations to make sure the parents understood what they were consenting to.

Because of the lack of blinding and informal sampling methods in all the studies except the Glasgow (2003) study, these studies are vulnerable to selection and assembly bias. Subjects chosen based on successful outcomes, will favour the use of an intervention. This method does not eliminate or even reduce the chance that an intervention may be unsuccessful in some cases.

4.3.4 Quality of Outcomes and Measurement

The quality of the outcomes and methods of measurement were based on their relevance, validity, reliability, timing and frequency. Adequate descriptions were required in order to determine that these critical components met the criteria and to be confident that the method of outcome measurement was conducted in an objective and unbiased manner.

4.3.4.1. Relevance: The CMOP-E model was used to categorize outcome indicators and influential factors found in the selected studies and to determine their relevance to occupational therapy (see Appendix A). A visual overview found in Table H16 depicts these factors as criteria for relevance. Checkmarks indicate that these factors were reported in the studies, not necessarily objectively measured. All the studies included at least one outcome measure related to physical functions and structures. Only one study discussed patient satisfaction, a factor considered to indicate a person's engagement in the process. Bonutti et al. (1994) reported patients were satisfied with the specific device; however, no measurement tools were used to measure this outcome. Patients were assumed to be satisfied if they were compliant, pain free and discharged the device when they were satisfied with the results obtained. This may well be a sign of the times, when the medical model was dominant and the patient was considered a passive consumer of health care. Today, the burn survivor's perspective has moved closer to the forefront as reflected in the work by Kooistra et al. (2009). According to Kooistra et al. (2009) the most important outcomes are those that measure patient satisfaction, relief of symptoms and feeling of well-being. Further discussion regarding the implication of this finding will follow in the conclusions section.

4.3.4.2 Validity/Reliability: The primary outcome found in all 10 studies involved a change in ROM, an outcome associated with the physical component of the person. Considering the definition of a contracture is stated as the ability to perform full ROM, it is logical to measure change in ROM to determine if the contracture has improved or resolved. Although the majority of the studies indicated ROM as an outcome measure, only three of the 10 studies could be considered as using valid and reliable methods.

When standardized methods are used to measure ROM with a goniometer, the results are considered reliable and valid (Lea & Gerhardt, 1995). The goniometer is a common tool and considered a valid instrument for testing ROM because we can assess

joint range from angular measurements (Portney & Watkins, 2000). Validity is based on anatomical knowledge, visual inspection, palpation of bony landmarks and accurate alignment of the goniometer (Gajdosik & Bohannon, 1987). To stress the importance of standardization, consider that there have been at least three different distal landmarks reported for goniometric measurement of dorsiflexion of the ankle (Lea & Gerhardt, 1995).

Johnson and Silverberg (1995) provide a good example of addressing validity and reliability in their report of using standardized methods with a goniometer. Measurements were taken by one of two therapists using specific methods with a reference of where to find a full description of the methods provided. This use of a consistent method established reliability and validity of the outcome measurements in this particular study.

Passive ROM measurements have been found to be less reliable than active ROM because the force used to apply passive stretch may fluctuate and therefore should be controlled. In addition, there may be less reliability if different therapists are measuring. (Gajdosik & Bohannon, 1987). However, the error associated with the lack of application of a standard torque and inconsistent positioning can be prevented. To address this problem, Glasgow et al. (2003) used a silver goniometer and a 500 g. constant force. Standard positions were used for all measurement and guidelines followed. Specific pre-conditioning sequence was used in order to counteract factors that may influence readings such as temperature and prior activity level. The study also tested reliability in this technique via test-retest measurements and blinding the therapists taking the measurement for the first 10 subjects. High intra-rater, inter-rater, and test-retest reliability of the TROM technique was established for this sample (intra-class correlation coefficients 0.993 to 0.998).

Bonutti et al. (1994) also reported using a goniometer to measure change in ROM in elbow contractures. When one considers that the starting position must be assessed visually, stabilization of the body part is a challenge and two hands are required to hold the arms of the goniometer and passively move the joint. There is a risk that the amount of tension could differ between therapists depending on the force applied and the ability to apply force to the forearm. Consistent therapists or methods determining amount of force improves reliability of measurement (Lea & Gerhardt, 1995; Gajdosik & Bohannon, 1987). In Bonutti et al. (1994), one independent physiotherapist did all the measurements thus positively addressing validity and reliability in their ROM outcome.

In the remaining studies, outcome measures could not be assumed to be reliable or valid and were considered to have questionable validity and reliability given the lack of reported tools or standardized methods to measure the outcome of ROM changes.

Secondary outcomes related to integumentary changes included three measures: state of collagen (Larson et al., 1971); presence of wound healing (Johnson & Silverberg, 1995); and absence of skin tears (Bonutti et al., 1994). Biopsy results provide pictorial proof of the changes that occur on a physiological level. It is reasonable to assume the information that is obtained through tissue biopsies is valid, and that reliability is trusted as specific knowledge, training and competence is required to perform a biopsy. Skin integrity data was not provided using any measurement tools and therefore is not considered valid, or reliable.

4.3.4.3 Outcomes as Health Indicators

Outcomes that fell under health indicators based on the Theory of Social Determinants of Health (World Health Organization, 2003) were tabulated to determine any similarities or trends in Table H13: Health Indicators. According to this theory, these indicators are considered influential in the successful treatment of health conditions. Included in the list are the following: economic circumstances (adequate food supply, transportation, and housing), employment security, social circumstances, social support, social relations; drug or alcohol dependence (including nicotine); and level of education. These indicators can be paralleled with the personal and environmental factors that were discussed in the background literature.

Only two of the 10 studies included a health indicator outcome, which was social support (Larson et al., 1971; Ridgway et al., 1991). In the study by Ridgway et al. (1971), poor social support for a pediatric burn survivor manifested into a failure to maintain adequate follow-up and resulted in severe contractures. The mother of the burn survivor neglected to engage the child in walking or his home program of exercises, nor had she brought him to any of his outpatient therapy appointments scheduled for five days a week. Transportation difficulties were reported as one of the barriers. After the young burn survivor was readmitted to hospital for a month long regime of serial casting under ketamine, he was discharged home with a more realistic home program (Ridgway et al., 1991). In Larson et al. (1971) the parents of another young burn survivor were considered to have cognitive challenges and did not understand or appreciate the importance of continuing the splint regime following discharge from hospital. As a

result, a severe flexion contracture of the left elbow developed. Readmission to hospital for two weeks of traction and a regime of static splinting to maintain the gains was instituted with success. The impact of adequate social support is obvious in these two examples and reinforces the importance of considering its influence in interventions. The impact of social support in relation to the CLR findings will be discussed further in Chapter 5.

4.3.5 Quality of the Interventions:

The quality of the interventions is based on the amount of detail provided in the studies to allow replication. Specific splinting and serial casting interventions utilize creep and stress relaxation principles to effect the change in ROM, therefore details related to how these principles were applied help determine the ability to replicate each intervention. For serial casting and splinting to treat a contracture, the goal is for the device to apply a sufficient load to force the fibers in the tissue to stretch and re-align to increase skin pliability and thus increase movement at the joint. It is the duration of the intervention that will enforce either the stress relaxation or creep principles (refer to Properties of Normal Skin and Scar in Appendix B to review principles related to creep and stress relaxation).

Referring to Table H14, the interventions were described in sufficient detail in five of the 10 studies (Glasgow et al., 2003; Johnson & Silverberg, 1995; Richard, 1986; Richard et al. 1995; Ridgway et al. 1991). The criteria are based on adequate detail regarding the technique, application protocols and duration of the intervention. Interventions are discussed according to the type: serial casting, static progressive splinting and dynamic splinting.

4.3.5.1 Serial Casting: Serial casting was the intervention under study in four out of 10 studies (Bennett et al., 1989; Johnson & Silverberg, 1995; Richard et al., 2000; Ridgway et al., 1991). They differ from splints in several features. One, these devices cannot typically be removed by the individual undergoing the treatment and two; they always encircle the entire joint creating a warm enclosed environment. They do use both the principles of stress relaxation and creep, stress relaxation for the initial application of the cast and creep during the extended period of wear between changes. This makes the variations reported in the timing of cast changes of import as it has the potential to affect the speed of contracture resolution. Serial casting involved bi-weekly changes in the

Johnson and Silverberg (1995) study, every 3.3 days (mean) in the Bennett et al. (1989) study, daily changes in the Ridgway et al. (1991) study, and was not specified in the Richard et al. (2000) study. In order to replicate this treatment, consistent and specified timing of cast changes is crucial and helps achieve confidence in the results of the studies. It allows us to compare one intervention result with another. It is this detailed reporting of the protocol including both the technique and timing of the intervention that helped determine that the three studies above could be replicated.

4.3.5.2 Static Progressive Splinting: Three out of 10 studies looked at static progressive splinting (Bonutti et al., 1994; Glasgow et al., 2003; Huang et al., 1978). This intervention uses a combination of stress relaxation and creep principles depending on the duration of device application and time between adjustments. Evidence of stress relaxation in tissues can occur in as short a time as five minutes, whereas creep is thought to require much longer than that. To have confidence in the findings and be able to replicate the study, the protocol needs to be explained in sufficient detail to determine the time between splint adjustments. Protocols for applying status progressive stretch were not mentioned in the Huang et al. (1978) study and it is difficult to determine if the static progressive splints were adjusted in response to ROM changes (static progressive) or some other method. The absence of standard protocols weakens the ability to replicate the findings from this study and understand the full impact of the results. Both Bonutti et al. (1994) and Richard et al. (2000) reported splinting programs that utilized a standard protocol for adjustments. The two protocols were described in enough detail to determine they were similar to each other, used stress relaxation principles and could be replicated. Despite the promise of using a consistent protocol, the specific protocol used in these studies had been established by the manufacturer of a commercial static progressive splint. It appears the decision to change the load application (tension) every five minutes to a maximum of 30 minutes was made arbitrarily without scientific evidence to support why this specific protocol was chosen. As a consequence, the results are subject to scepticism.

4.3.5.3 Dynamic Splinting: The amount of tension enforced across contractured joints in serial casting and splinting can vary depending on the therapist or the torque mechanism in the splint. Because dynamic splints apply a constant tension across the joint, the amount of tension is a critical aspect of the intervention.

Dynamic splints were the intervention studied in three of the 10 studies (Glasgow et al., 2003; Richard, 1986; Richard et al., 1995). The amount of tension employed during dynamic splinting was described using inconsistent terms in the studies above; both torque and tension are referred to. In addition, tension was measured using two different systems, metric and imperial. In spite of these differences, from a theoretical perspective, the use of dynamic progressive splinting could be replicated using similar tension and frequencies in the inpatient setting. However, in order to compare the results of these studies with each other, a common method of reporting dynamic splint settings is required.

4.3.5.4 Static Splinting: Static splints are used to provide support and immobilization and are considered for purposes of prevention and protection rather than correction (Fess & Philips, 1987; Morrey, 1995). Three out of 10 studies reported static splinting as one of the interventions under study in relation to elbow contractures (Huang et al., 1978; Larson et al., 1971; Richard et al., 1995). This makes sense in the Huang et al. (1978) study which included the use of splints during the time period before the burn survivor developed a contracture and in the Larson et al. (1971) study, which included the use of static splints to maintain correct position. In the study by Richard et al. (1995), the static elbow extension splint was applied at night only on one elbow and its effectiveness compared to the dynamic splint on the other elbow. To keep to the purpose of correction of contractures, the results from the use of the dynamic splint is considered alone.

4.3.5.5 Contamination: The issue of contamination was not applicable for most of the studies due to there being only one group. In studies with more than one group, possibility of contamination was scrutinized. The Glasgow et al. (2003) study acknowledged contamination due to two subjects crossing over. Consequently, the subjects eliminated to prevent skewing the results. The only other study where contamination was possible was in the Richard et al. (2000) study. The study compared two groups, stating that the progressive group received splinting or serial casting alone, while the other group received multimodal treatments. Standard treatment for burn contractures is multimodal including stretching (exercises), massage pressure and activities, and it would be unlikely that any of these treatments would be withheld due to ethical implications, therefore it is likely that the progressive treatment group received multimodal treatments before the serial casting or splinting. This contamination can

reduce the difference between the groups in favour of the control group according to the McMaster CLR guidelines (see Appendix C).

4.4.5.6 Co-interventions: The presence of co-interventions is the last point to consider under interventions, considered a source of intervention bias. Co-interventions were present in all 10 studies. These were vaguely described in five of the 10 studies using vague terms such as vigorous physio, physio sessions, home program, functional activities, other treatment, standard treatment and various other treatments (Bennett et al. 1989; Glasgow et al. 2003; Larson et al., 1971; Richard et al., 1995; Richard et al., 2000; Richard, 1986). These vague descriptions make it difficult to address the impact these interventions may have had on the results, though the presence of any co-interventions raises the question of whether the actual intervention under study was responsible for the changes or did the co-interventions play a role.

Further details regarding the co-interventions increase the concern regarding their impact on the results. Passive ROM has a known effect on range of motion and was reported in five of the 10 studies (Glasgow et al., 2003; Huang et al., 1978; Johnson & Silverberg, 1995; Richard et al., 1995; Ridgway et al., 1991). Another co-intervention mentioned in two of the studies was the administration of a sedative prior to the application of serial casting. A sedative allows the therapist to apply increased tension across the scar contracture without the resistance caused by pain. This allows for a better stretch and thus influences the results.

The only case where the issue of co-intervention was intentionally ignored is in the case study by Larson et al. (1971). The authors were bringing attention to the idea that there are various techniques that could make a difference (rather than accepting contracture as unavoidable) and did not specify their intent as wanting to demonstrate the effectiveness of one type of intervention. Essentially this groups all the co-interventions into the intervention variable under study and makes it impossible to assign effectiveness to one specific intervention.

4.3.6 Quality of the Reported Results

At first glance, reported results indicate that contractures improved or were resolved in all 10 studies with the use of splinting or serial casting (see Table H12). To determine the confidence we can assign to these findings, a critique of their quality was completed. The McMaster review guidelines focus on the quality and validity of

statistical reporting, appropriateness of analysis and clinical significance of the reported results (Law & McDermid, 2008). Refer to Table H14: Evidence Table for an overview of the methodological quality of the reported results.

4.3.6.1. Statistical significance: Reporting results of quantitative research studies in terms of statistical significance begins with the determination of whether the authors used any statistical tests at all (Greenhalgh, 2010). Only two of the 10 studies used statistical methods to prove their numbers meant something (Glasgow et al., 2003; Richard et al., 2000). These two studies tested their theories about the effectiveness of the intervention under review using inferential statistics to report results thus warranting further attention (Glasgow et al., 2003; Richard et al., 2000).

Glasgow et al. (2003) found that there was a significant preference for daily total end range time (via splints) of between six and 12 hours to obtain faster resolution of contractures using a two-tailed sequential plan to show treatment preference. In sequential clinical trials (SCT), quantitative measurements are used to indicate a preference for A or B (dichotomous judgement). The plan was pre-selected based on the chosen effect size (0.75 in this case), and acceptable risk of Type I and Type II error (0.05 for both). The power of the test indicated a 95% chance that the boundary had been crossed correctly. The statistical outcomes from SCTs are considered valid according to Portney and Watkins (2000).

Richard et al. (2000) found the difference in days to correct a contracture significantly in favour of the progressive treatment group which used serial casting and splinting as an intervention. Inferential statistical techniques were used to determine the differences in the means of the pediatric and adult group with respect to four parameters related to scar contractures and whether the differences were significant. It is assumed that a t-test was used to compare means but it is not indicated in the study. Attempts were made to contact the author for clarification without success so far. Two parameters investigated were found to be significant, initial contracture development and contracture severity. Because inferential statistics are accepted as a method for making forecasts and inferences, the study results that underwent inferential statistical analysis are considered more likely to be valid and applicable to other burn survivors with contractures. The small sample size reduces the confidence in applying these results to the general population.

4.3.6.2 Appropriateness of analysis: Methods that were used to describe and analyze data were examined and resulted in the discovery of three levels of statistical data reporting in the accepted articles: raw, descriptive and inferential. Descriptive statistics serve as a tool for describing and summarizing data whereas inferential statistics is a formalized body of methods for finding out information for an entire population based on the data from a small sample (Glass & Hopkins, 1970). To critique the appropriateness of the analysis methods of the included studies, results are discussed according to the level of statistical data reporting.

Raw data: Empirical observations were presented as raw data in four case studies (Johnson & Silverberg, 1995; Larson et al., 1971; Richard, 1986; Ridgway et al., 1991) accepted as an appropriate method of presenting data in case studies considering there is no comparison data. The traditional style of research reports that include data analysis does not always suit the case study (Bowling, 2007).

Johnson and Silverberg (1995) provided raw data in narrative form along with one table to illustrate the changes in ROM for each ankle according to pre and post measurements. They reported that ROM increased in bilateral ankles post serial casting and was maintained at one year follow-up. Missing are measurements for the outcomes of skin integrity and functional activities or a clear description of what the specific changes were and therefore it is difficult to determine what these changes mean in terms of applying them to other cases.

Larson et al. (1971) reported that scar tissue is responsive in its early stages and reacts favorably to corrective measures such as traction, pressure and exercises. The effect of traction or stretch on collagen fibre was examined using tissue biopsies. Findings showed a change in collagen patterns from an irregular pattern with nodule formation to a pattern of parallel alignment with two weeks of traction. A biopsy, forty days after traction was discontinued, determined that the parallel alignment was maintained by a static splint with a pressure bandage underneath.

Additional quantitative data would have strengthened the argument, although quantitative techniques to measure change in tissue biopsies likely were not available at that time. Specific range of motion measurements would have been helpful for the reader to understand the amount of improvement that occurred with each technique and in what time frame.

Richard (1986) presented raw data on ROM measurement changes within the narrator description of the intervention. Results were not clearly delineated, e.g. results

were reported as degrees lost and gained on each of first four days of splint application as reasons for changing tension. The final outcome pre-discharge was described in general terms as full and normal ROM. This information could have been presented more clearly with data summarized through simple addition of the pre and post outcome measures to help the reader see the magnitude of change resulting from the use of the device, in this case 55 degrees of extension in one elbow in four days.

Ridgway et al. (1991) reported that 6 days of serial casting resulted in increased ROM in burn related ankle contractures using raw data (degrees of ROM), and that the patient progressed from non-ambulatory to independent ambulation with one month of inpatient rehabilitation. Providing the raw data allowed the reader to see that the difference after serial casting was large and adds credence to the results.

Overall, raw data is an appropriate method to describe the results in the four case studies, however, their applicability to other cases or to the general population is limited.

Descriptive Data: As mentioned earlier, descriptive statistics serve as a tool for describing and summarizing data. Data cannot be quickly and accurately interpreted unless they are organized into a pattern and statistical summaries provided (Glass & Hopkins, 1970). Graphs, charts and/or tables were used to present the data. Descriptive statistics were used in four of the 10 studies (Bennett et al., 1989; Bonutti et al., 1994; Huang et al., 1978; Richard et al., 1995).

Bennett et al. (1989) study was a good example of an appropriate analysis of descriptive data regarding ROM changes after serial casting. Data analysis involved using measures of central tendency to demonstrate the effectiveness of serial casting with the overall mean values for ROM before and after intervention provided as well as the range values. The authors reported large increases in ROM-56% of normal ROM (range 0-93%) improved to 86% of normal ROM (range 29-100%). The remaining results were described in general terms as follows: all wounds continued to heal; serial casting prevented or delayed need for surgery; elbow and knee joints had best results compared to wrist and ankle; and gains were lost if patient did not comply with subsequent splint usage. These general descriptions may provide insight into some of the factors that need to be considered when planning future research, however, they cannot be considered under results without support from objective measurements.

Bonutti et al. (1994) tabulated the individual results of 20 cases and then reported the results in narrative form using averages calculated from the individual data. They

reported an overall average increase in motion of 31 degrees (69%), with an average of 17 degrees in extension and 14 degrees in flexion post SPS splinting.

This descriptive-data in raw form with some measures of central tendency allows the reader to understand the data and see the variations within the sample. The analysis was incomplete as the standard deviation of the scores is missing. To describe the variability in the sample, the variability measure range was used. The range showed a wide dispersion of values from 0 degrees to 65 degrees when looking at extension and flexion goals separately. Range is considered an unstable measure and is greatly influenced by the sample size, whereas, the standard deviation has the property of consistency (Khazanie, 1986). The authors did not explain why they chose to combine the results for both extension and flexion changes. In order to claim support for the theory of stress relaxation using SPS, it would have been appropriate to report the changes in ROM for the specific motion(s) that the splint applied SPS principles on. In some (not all) cases both flexion and extension were treated with SPS. No data analysis was done to describe characteristics of the sample making it difficult to determine if the findings can be applied outside the study. The remaining results were described in general terms as follows: no cases of significant pain with use of orthoses; compliance determined to be excellent based on finding that no patient discontinued use of the orthotic on their own and if therapy was performed for extension, an improvement in flexion was also noted. Similar to the Bennett et al. (1989) study these general descriptions may provide insight into some of the factors that need to be considered when planning future research, however, they cannot be considered under results without support from objective measurements.

Huang et al. (1978) used descriptive statistics to describe the data and identify group patterns for contractures using ordinal data. They secured a large mass of data and organized it into frequency distributions. The authors also provided grouped percentage frequencies which revealed the distinct pattern of contractures incidences and splint use. The authors reported finding that the incidence of deformities from burn scar contractures was reduced in patients who underwent a regime of pressure and splints and the duration of splint/pressure appeared to play a role. Descriptive data is not sufficient for establishing relationships between variables according to Portney and Watkins (2000). In an exploratory research design such as this one, the process of correlation (measure of degree of association among variables) is typically used (Portney & Watkins, 2000). To provide a descriptive measure of the degree of relationship or association between the

two variables, splinting and contractures, measures of correlation are required. Employing correlational statistics to establish the degree of relationship between these two variables allows the findings to be interpreted with more confidence as demonstrated by the work done by the author of this McMaster CLR following.

Because measures of correlation exist for lower levels of measurement, the authors could have analyzed the data as dichotomies (presence/absence of intervention and presence/absence of contracture) using the Phi coefficient recommended for nominal levels (Chatburn, 2010). To demonstrate, the writer calculated the Phi coefficient to be .448 (see Figure F3. Computation of Phi Coefficient for specific computation details).

We can interpret the strength of this association (.448) as weak to moderate based on a range of -1.0 to +1.0 (Portney & Watkins, 2000, Chatburn 2010). The ability to establish the strength of the association increases the confidence in the value of this result. The other result reported by Huang et al. (1978) is that the need for surgical release of contractures was reduced by the use of splint/pressure intervention and was illustrated using a histogram to describe the percentage of surgical releases required by 625 patients in those who had the intervention and those who did not. Confidence in this result is seriously affected by selection bias. Refer to Table H15 for definition of specific biases. Other limitations of the study bring into question the validity of the findings such as the reliability of the data due to its retrospective nature. The accuracy and credibility of data source is a consideration that may indicate a measurement bias from incomplete data (Portney & Watkins, 2000).

The fourth study that used descriptive data was the Richard et al. (1995) study in which raw data was provided in narrative form and a graph was used to depict the change in ROM each day the splint was in use. The authors reported that the dynamic splint increased the ROM in one elbow in 11 days and maintained range until discharge eight days later while the range in the other elbow decreased with the use of the static splint. As mentioned previously, because the static splint appears to be an intervention for prevention and immobilization rather than correction, the results of the dynamic splint are considered separately (Fess & Philips, 1987; Morrey, 1995). When considering the results of the dynamic splint on its own, the graph was effective in pointing out the dramatic increase in range in a short period of time. Because the intent of the study was to demonstrate that one intervention was better than the other, a hypothesis to that effect was required with testing through the use of inferential statistics and so the analysis was considered insufficient for determining the differences in effectiveness.

Descriptive statistics are thought to be useful for summarizing and describing important features of the data and as building blocks for further synthesis and data analysis (Portney & Watkins, 2000).

Inferential Data: Because inferential statistics are accepted as a method for making forecasts and determining relationships among variables, the results found in the two of 10 studies that reported inferential data are considered more likely to be valid and applicable to the general population of burn survivors with contractures (Glasgow et al., 2003; Richard et al., 2000). The results of these two studies were discussed previously under 4.3.6.1: Statistical Significance. Further to that, the results of the critique regarding their data analysis will be reviewed.

Richard et al. (2000) used descriptive statistics such as measures of central tendency to describe changes in ROM observed after treatment; however, the age groups were compared using inferential statistics. Differences between adults and pediatric burn survivors were calculated by comparing means. A possible explanation for not using inferential statistics to compare the means of the progressive versus the multimodal group in days to correct contractures was because the difference was large enough to be obvious. The authors reported that the days to correct contractures were 35.0 ± 35.0 in the progressive group versus 76.2 ± 89.3 days in the multimodal group.

Glasgow et al. (2003) applied appropriate analysis techniques in their SCT, however, "the rejection or acceptance at a single level of significance hardly constitutes a full analysis" Whitehead (1997, p. 135). Their findings showed a significant preference for group B, the group that utilized splints for a longer period of time (between 6-12 hours) demonstrated in the following results - of 16 pairs, 11 preferences were for group B, 1 preference for group A and 4 ties. According to Whitehead (1997), the sequential analysis yields evidence concerning efficacy and needs to be interpreted and considered together with other aspects of the trial findings. They included information on the effect of the degree of pre-treatment joint stiffness as a possible influence on final TROM and reported it was not found to influence it. Although group A all had dynamic splints, whereas group B had both dynamic and static progressive splints, further analysis within group B revealed that the average increase in ROM for the dynamic splint users versus the static progressive splint users was insignificant.

Overall, there were five out of 10 studies that applied sufficient appropriate statistical analysis.

4.3.6.3 Drop-outs: Subjects may drop out of a study during the data collection procedures. Because there may be more drop outs in one group than in others, this could cause the groups to differ or result in systematic differences in the groups that remain resulting in biased findings (Brink et al. 2006). In case study designs and the before and after case series, subjects were chosen retrospectively according to their participation in an intervention, therefore the issue of drop outs is not applicable. Bennett et al. (1989) had no drop outs among the 15 subjects included in that study while Glasgow et al. (2003) described 11 drop outs. Reasons given were non-attendance at therapy in six cases, an inability to tolerate splints in two cases, change in treatment plan for one case, and two crossed-over due to non –compliance. These drop outs were appropriately handled by comparing baseline characteristics between subjects who dropped out of the splint program and subjects who went on to become part of the final sample using descriptive analysis. Only minor differences were found.

In the Huang et al. (1978) study, 51/406 patients who received intervention were reported to have worn splints for less than six months. Within this group, subjects were reported to have discontinued therapy for reasons of non-compliance, discomfort, pain and open sores. Their data was retained in the group that wore splints for less than six months. Garson (2009) discusses possible mortality bias related to patterns that occur in drop outs. The symptoms experienced by these drop-outs indicate a pattern of possible increased burn severity compared with those in the group who may have discontinued the use of splints for other reasons such as contracture resolution. When considering the increased incidence of contractures reported in this group compared to those subjects who wore splints for more than 6 months, one wonders if the subjects in this group may have had a greater degree of joint deformity which could have influenced the end result.

Of special consideration is the Richard et al. (2000) study which was retrospective and based on successful cases only. There were no drop outs in the typical sense of the term; however, drop outs were excluded from the beginning. The authors discussed the fact that the study only included those cases in which burn scar contractures were amenable to physical rehabilitation and excluded those who failed a trial of therapy. It is possible if one was to look at excluded subjects in this study as the equivalent to drop outs, that the excluded subjects (drop outs) may be systematically different from those who remain, and may result in biased findings(Brink et al., 2006).

4.3.6.4 Clinical Significance: As pointed out in the McMaster Critical Review Form

guidelines, the relevance of the results to clinical practice helps determine if the results of a study are important clinically. All 10 studies reported the results in terms of clinical importance, discussed in the final conclusions section in Chapter 6.

4.3.7 Quality of Reported Conclusions

The quality of reported conclusions was based on their relevance and reliability given the study methods and results. Limitations of the studies are presented in conjunction with the conclusions. Because of the heterogeneity found in relation to the quality of their conclusions, the 10 studies are presented individually beginning with the two studies that met all the criteria (Glasgow et al. 2003; Johnson & Silverberg, 1995).

Glasgow et al. (2003) concluded that for the study sample, a daily TERT of greater than 6 hours per day facilitated contracture resolution at a faster rate than a daily TERT of less than 6 hours a day, over four weeks of splinting. This conclusion is clearly related to the results of the study. The limitations were identified as problems with random assignment and the potential for experimenter bias and instrument bias due to poor recall in self-reports. Randomization in this study was unsuccessful in obtaining a matched and balanced set of patients in treatment A and B before the trial was stopped despite using a permuted block design, recommended to achieve an early balance (Tooth, 1999). Random assignment rather than selection assists in assuring internal validity rather than external validity (Trochim, 2006). Because of the limitations of the study, the authors recommended further research to confirm the findings.

Johnson and Silverberg (1995) concluded that the success of one particular case indicated serial casting may be effective for treating contractures related to burns. This conclusion is appropriate given the use of qualifiers such as the “particular case” and “may be effective”. The ability to generalize these findings to the general population is limited due to the case study design with no control or comparison. The responses of one individual do not always bear resemblance to those of others in similar circumstances (Portney & Watkins, 2000). The authors went on to conclude that the cast allowed for effective wound healing by preventing scratching and was a conservative, cost-effective approach compared with serially changing thermoplastic splints or surgical release. These conclusions were not considered appropriate as they were supported by any measurement or data. Multiple interventions at the same time as serial casting make it difficult to establish cause and effect although the dramatic change post serial casting increases

confidence that the intervention caused the increased ROM. As in the previous study, the authors recommended further research is required.

The remaining 8 of the 10 studies did not meet all the criteria for their conclusions to be deemed appropriate.

Bennett et al. (1989) stated that serial casting provided immediate results (within hours), and claimed the use of sustained stretch will increase ROM by slowing the contractile process of burn scar. This conclusion was not substantiated by discussion or results to demonstrate a temporal relationship between serial casting and the contractile process of burn scar. Because of the lack of a control group and multiple co-interventions, it is not possible to declare causal effectiveness of serial casting on contractures. Authors stated that casting over open wounds does not delay healing. This statement was supported by reference to a previous study, however, it would be more appropriate to state that the results of the study may support the idea that casting does not impair healing in non-infected open wounds rather than declaring the ability to establish a definitive relationship and generalize the result as true of all open wounds. If a cast was applied and left in place over an infected wound, wounds could potentially get worse without daily inspection and treatment. Authors also concluded that serial casting was accepted well by patients; however, there is no data to support this claim. Data collection and analysis was limited, significant functional losses were reported as an outcome of burn contractures; however, this outcome was not measured despite having the opportunity as a prospective study to do so.

Bonutti et al. (1994) concluded that SPS is a successful method to re-establish ROM using the specific protocol of 30 minute sessions explaining that gradually applied loads result in tissue responding in more compliant manner with plastic deformation and once plastic deformation of soft tissue is obtained, elongation of tissue is maintained. This conclusion cannot be made given the study design and lack of control. "Case series belong to a group of descriptive studies that do not test the hypothesis of treatment efficacy" (Kooistra, 2009, p.21). Expert subjective opinion was the basis for concluding the tissue response of plastic deformation, objective measures such as biopsies or amount of skin pliability are required to validate this statement.

Huang et al. (1978) concluded that in order to derive any benefits from splints/pressure across joints, they must be worn for a minimum of 6 months and that contracture deformities, once established, are not affected by splints/pressure based on their finding that 92.7% of 219 who did not wear any splints required at least one surgical

release. As the conclusions are based on descriptive stats, causal inferences cannot be made. Stating that splints/pressure should be used a minimum of 6 months was not statistically supported, though the data tables did illustrate the possibility of such a pattern.

Larson et al. (1971) concluded that scar contractures and scar formation following burns can be sharply decreased by proper positioning of the patient, utilizing splints and skeletal traction during healing and long term use of splints and pressure following healing. Given the case study design, no point of comparison and descriptive nature of the data, a causal relationship cannot be established between the interventions and condition and therefore, the conclusion is deemed not appropriate. The statement made earlier in the article, that contractures may be prevented with the use of splints and pressure, would be more appropriate suggesting a possible relationship that requires further investigation.

Richard (1986) did not provide clear conclusions and did not clearly relate the results of the 55 degree improvement in elbow contracture post SPS splinting as support for the theory that progressive stretch is effective in reducing contractures related to burn injuries. In his conclusions, Richard stated that the Dynasplint™ presents an objective approach to applying static progressive stretch since the force level is controlled by an adjustment mechanism built in to the splint. This may be true; however, without a background discussion on the implication of an objective approach to applying pressure, the conclusion is not meaningful. The author concluded that a more conscientious effort to apply the splint during the day lessened the degree of elbow contractures and resulted in normal ROM at the time of patient discharge. To assign a causal link to splint application and degree of elbow contractures requires an experimental approach to support it and therefore is not considered appropriate (Brink et al, 2006).

Richard et al. (2000) concluded that the use of progressive types of physical interventions appears to be more effective in the correction of scar contractures than that of a multimodal approach and that and that scar contractures that appear within the first two months have a good prognosis for resolution through rehabilitation. Cause and effect was not established as it was not an experimental design. In addition, Crombie (2007) cautions that researchers should not compare outcomes when cohorts of patients who received different treatments are identified because whatever the basis for choosing the different treatments, the two groups were likely to be different before they were treated..

Richard et al. (1995) concluded that the use of a dynamic elbow extension splint

demonstrated superior results in improving elbow extension compared with a static splint. The static splints described in the study appear to be simple static with no progressive changes making it difficult to compare their biomechanical underpinnings. Constant tension or "creep" was the appropriate biomechanical principle stated for the dynamic, while stress relaxation principles are typically associated with the use of static progressive splints rather than static splints. The use of the term static splint enters an element of uncertainty regarding the construct validity and subsequently the conclusion. Construct validity concerns the theoretical conceptualization of the intervention and response variables and whether these have been developed sufficiently to allow reasonable interpretation and generalization of their relationship (Portney & Watkins, 2000).

Ridgway et al. (1991) provided conclusions that did not follow the results. The case study reported on changes in ROM and function of the burn survivor, yet the discussion at the conclusion of the paper centered around serial casting and its effect on hypertrophic scarring and connective tissue alignment. An appropriate conclusion is that in this case, serial casting was effective in correcting soft tissue contractures as supported by the large change in ROM measurements after 6 days of serial casting.

To summarize, only two of the 10 studies met the quality criteria for appropriate conclusions. The remainder could not be deemed appropriate due to problems with construct validity, statements of causality in non-experimental designs, or statements concluding a presence of relationships without appropriate data or data analysis to support these claims. Despite the shortcomings found in the conclusions, there is still merit in the findings from these studies. Chapter 5 will highlight the key points from the data to form the basis for the conclusions of the integrative McMaster CLR.

4.3.8 Quality of Evidence

The quality of evidence presented in each study was ranked as conclusive, inconclusive and insufficient based mainly on methodological quality found during the individual critical appraisals. Conclusive, inconclusive and insufficient evidence was determined according to strong, moderate and weak methodological quality (respectively). Methodological quality was evaluated according to whether the study met the criteria in the McMaster guidelines and is reflected as yes/no responses (see Table H14).

The incidence of risk of bias in the included studies is portrayed in Table H15: Risk of Bias. Bias is defined as*: "any influence that produces a distortion in the results of a study or that strongly favours the outcome of a particular finding of a research study*" (Brink et al., 2006, p.198). As there is no such thing as an absolute bias-free design, researchers are expected to put into place methods to prevent or reduce the risk of bias as much as possible. Several patterns of bias were detected in the included studies beginning with the risk of intervention bias. The presence of co-interventions was found across the board confounding the effects of the intervention under study and resulting in the risk of intervention bias. Another risk of intervention bias was due to multiple therapists, found common in the studies except for Johnson and Silverberg (1995) who reported consistent therapists applied the intervention under study and Bonutti et al. (1994) who looked at self administered interventions. The use of an independent evaluation rater was reported in Richard et al. (2000) to avoid this measurement bias.

Because risk of bias can impact confidence in study results, the risk of bias found in the individual study was taken into consideration when ranking the methodological quality of the evidence. Table H15 display the details of individual studies and specific biases.

CHAPTER 5. DISCUSSION

The specific research questions addressed in this McMaster CLR were: 1) Is the methodological strength of the evidence such that splinting and serial casting can be considered an effective intervention to improve elbow contractures in burn survivors? 2) Is there sufficient evidence to support the use of one type of orthotic over another? 3) What evidence is there to warrant consideration of mitigating factors that may influence the effectiveness of splinting and serial casting? This paper reviewed the related research literature spanning a period from 1963 to 2009 to obtain sufficient research information to address these questions concerning the effectiveness of splinting and serial casting as treatment for contractures in burn survivors.

To address the first question on whether the methodological strength of the evidence is such that splinting and serial casting can be considered an effective intervention to improve elbow contractures in burn survivors, key points regarding the overall methodological strengths and weaknesses of the research are discussed as they provide support and guidance in determining the answer. The second question as to whether there is sufficient evidence to support the use of one type of orthotic over another is addressed within the methodological weaknesses of the studies discussed below. Relevance of the findings is discussed according to the CMOP-E model to support their clinical relevancy and determine where the gaps lay. The third question regarding whether there is evidence to warrant consideration of mitigating factors that may influence the effectiveness of splinting and serial casting is discussed in detail under 5.3 Mitigating Factors Studies. To complete the discussion, limitations of the review will be considered.

5.1 KEY POINTS FROM DATA

The key points from the findings will be discussed according to three aspects of the research reviewed: strengths, weaknesses, and context.

5.1.1 Strengths of the research studies reviewed

The strengths of the research reviewed were in the consistency, directness and feasibility of the findings.

As all the included studies were similar in purpose, the first strength of the research studies arises from the summary related to the main outcome of interest, that of reducing contractures. It is of interest that for all the studies, a consistent result was

found. An increase in ROM after splinting and/or serial casting a contracture was the result in every study. Although five studies involved single subjects only, an argument has been presented that when single case studies follow the same pattern as another, they may be considered together as a form of case law described earlier (Portney & Watkins, 2000).

Another strength identified was the directness of the findings: This term refers to the applicability of findings to one's own setting and/or population (Jones, 2010). All 10 studies were completed on burn survivors with contractures in the natural clinical setting, rather than a laboratory. This increases confidence that study results were not influenced by artificially created settings and that the results can be applied to the typical clinical setting where interventions in burn rehabilitation occur. Generalizing the results to the population of burn survivors with joint contractures is not always possible as seen in the Huang et al. (1978) study, in which the characteristics of the sample were not described in any detail. On the other hand, the majority of the studies did describe the burn survivor's characteristics including gender, age, TBSA and presence of contracture making it possible to relate the findings to the population encountered in the clinical setting.

Feasibility refers to the ethical and practical application of the results or replication of the studies. All interventions (other than the outmoded use of skeletal traction) under consideration to improve joint contractures are considered practical, ethically acceptable and justifiable. There was no withholding of known effective treatment and the few adverse affects reported were minor, preventable and temporary (see Table H12 for list of adverse affects). Pertaining to replication, in spite of the missing details in some of the studies regarding the exact application of the splints, enough details were provided to allow replication based on the concepts of how the intervention works rather than the specific design, or name of the splint.

5.1.2 Weaknesses of research reviewed:

Weakness in the research reviewed was found in the following areas: lack of conceptual clarity, difficulty establishing cause and effect, and problems with reliability and validity in data collection.

Concepts have been described as the building blocks of theories and vary in level of abstraction (Reid et al., 2002). Understanding the concept of tissue elasticity and its response to stretch is one of the building blocks necessary to connect new knowledge

obtained through data collection methods to the existing and developing body of knowledge. Larson et al. (1971) provided the first evidence related to accepting the concept of tissue elasticity and its response to stretch through biopsies post traction. An objective empirical approach to determine the physiological effects of prolonged stretch on tissue is through tissue biopsies. In the absence of a representative animal model of human hypertrophic scar, tissue samples are usually obtained from humans. As this is an invasive procedure done under anesthetic, its inclusion in studies looking at splinting and serial casting is limited (Engrav, Garner, & Tredget, 2007). The results pre and post traction showed increased length of tissue and a change in collagen towards re-alignment or normalization. The abnormal whorl-like patterns of collagen formed during scarring are thought to decrease a skin's pliability and flexibility required for normal joint range (Tredget et al., 2006).

An example of how a lack of conceptual clarity can affect the meaningfulness of the study is found in the Richard (1986) study. This case study discovered useful, meaningful results from the use of a dynamic progressive stretch device. However, rather than describe the concepts and theory behind the effectiveness of this type of intervention for contracture resolution, the focus appeared to be on supporting a specific commercial splint. Inclusion of information regarding benefits associated with manufacturer's instructions, versatility in available sizes and cost benefits of reusability supported the premise that the provision of a trial device from the vendor-manufacturer likely introduced bias. In effect, this clouded any scientific reasoning for the success of the intervention or how the results successfully fit within the context of the underlying concept. As pointed out by Garson (2009), case reports should cover their focus in depth and this focus must test propositions which are relevant to significant theoretical issues. This review found similar issues in the Richard (1995) study, the only study that attempted to compare two different types of orthotic interventions. Without descriptions of the underlying principles being used for each orthotic interventions, it was difficult to make the comparison.

Establishing absolute effectiveness or a correlation between variables was made difficult due to the paucity of quasi-experimental designs and methodological flaws in the descriptive or exploratory designs meant to explore cause and effect. The sequential clinical trial design used in the Glasgow et al. (2003) study presents a potential solution to the ethical dilemma of not providing treatment to a control group. With low sample size requirements in this design, the benefits of treatment could be realized quickly and

those in the control group could be offered the preferred treatment in a timely manner. In addition, the data analysis was not always sufficient to establish the presence of a difference or a relationship. For example, the Bennett et al. (1989) study collected ratio level data and two sets of data for each observation. Had the authors applied further statistical analysis of the data using a paired statistical test, a relationship between the variables could have been explored (Greenhalgh, 2010).

Another example of difficulties with establishing absolute cause and effect concerns wound healing and serial casting. The Johnson and Silverberg (1995) study monitored wounds between cast changes in response to this concern and found that all open areas that were smaller than the size of a quarter initially were unchanged or improved in appearance when checked daily. The finding that the wounds continue to heal under serial casts is also supported in the literature by a study by Ricks and Meagher (1992) that evaluated the efficacy of plaster casting in the treatment of newly grafted lower extremity burns. The results showed that the casted group had significantly fewer days from skin grafting to wound closure and a higher incidence of complete graft take (Ricks & Meagher, 1992). However, the risk of skin breakdown remains a consideration when utilizing serial casting as seen in the adverse effects reported in the Ridgway et al. (1991) study which reported incidences of excoriation and in the Silverberg and Johnson (1995) study which reported skin irritation with silicone inserts under the cast. Wounds were described in one of the studies as "open areas smaller than the size of a quarter" and results were described as "unchanged or improved on daily checks between casts" (Ridgway et al. 1991, p. 69). This general description of the wounds makes it difficult to determine if there truly was effective wound healing to support their conclusion. A standard wound assessment would have strengthened this finding and subsequent conclusion.

Methodological concerns included lack of reliable, valid data collection methods and insufficient reporting of analysis methods. Reliable, valid data collection methods are crucial in order to have confidence in the findings from these studies and played a large part in determining the final ranking of evidence quality. Seven of the 10 studies with results that could not be considered valid or reliable had to be ranked either inconclusive or insufficient in large part due to this fact. Despite the common use of the goniometer in measuring ROM, this method is not the only one available for measuring ROM and therefore cannot be assumed. Details regarding the tool and methods used to standardize protocols need to be included in research studies to ensure reliable and valid

data is collected. In addition, as pointed out earlier, outcome measurement was limited to physical functions and structures without considering other possible mitigating factors in the success of rehabilitation interventions. Further discussion on this matter will follow in section 5.3 Studies Related to Mitigating Factors.

Methodological flaws introduce risk of bias. Some biases may be unavoidable such as recall/memory bias in collecting retrospective data or the influence of co-interventions found in all the studies, Researchers are responsible for avoiding co-interventions as much as possible and recognize their influence as demonstrated by Johnson and Silverberg (1995) in their suggestion that the case report indicated that the success of the intervention (serial casting) may be influenced positively by premedication, proper bony alignment, consistent cast changes and close monitoring of wounds. It would be highly controversial, but not impossible nor unethical in some circumstances, to withhold co-interventions that have been standard practice for years.

5.1.3 Context

All the research studies reviewed used quantitative research designs and methods. It has been suggested that "*an integrated approach using qualitative research can strengthen health and human service inquiry*" (Reid et al., 2002, p. 266). Although no qualitative studies were accepted in the review, the gap is recognized and mitigating factors that are often addressed by qualitative techniques will be discussed further under Mitigating Factors Studies in section 5.3.

5.2 CMOP-E ANALYSIS

Relevance to clinical situations in which occupational therapists' practice was examined using the CMOP-E model as the basis for identifying key components considered important. Key components found during the critical review of the accepted articles were categorized according to person, environment, occupational purposes and engagement. Refer to Table G16 for a descriptive overview of the components found in the 10 included studies.

Only two components of the CMOP-E model were considered as outcomes in the included studies, that of physical function/structures and satisfaction. All the studies included outcomes of physical functions or structures considered a performance component within the person. Satisfaction as a component of engagement was taken into account as an outcome in the Bonutti et al. (1994). Unfortunately this outcome was

reported as “no cases of significant pain” and “patients were satisfied with this rehabilitation approach” (p.133), without employing standardized methods for determining this outcome. The remaining components that were addressed within the studies are identified in Table G16 and not considered outcomes as there was no objective outcome data.

The next section discusses studies found during the comprehensive search that relate to mitigating factors. This contextual material was reviewed with a critical perspective; however, this body of research did not form part of the actual methodological quality review subjected to the detailed evaluative critique using the McMaster forms and protocols.

5.3 MITIGATING FACTORS STUDIES

The results of this review have revealed a propensity for uni-dimensional physical outcomes for studies that explore the effectiveness of splinting and serial casting. To enable burn survivors to participate in occupations, the occupational therapist looks not only at the physical requirements to perform an occupation, but also at the factors that may influence their participation. The clinician working with burn survivors often observes the obvious influence of mitigating factors such as motivation, compliance, social and financial support on rehabilitation outcomes. Although no outcome studies were retrieved that met all the splinting/serial casting inclusion criteria to be included in the critical appraisal process, the mitigating factors findings are important to answer the third question of the integrative McMaster CLR. Is there any evidence to warrant considerations of mitigating factors that may influence the effectiveness of splinting and serial casting?

The comprehensive search uncovered thirteen studies that looked at several mitigating factors related to intervention outcomes (see Table D9). The first two studies look at the effect limitations caused by burn injuries have on quality of life (QOL). Consider the bi-directional nature of the “bridge” of occupation to and from the person and environment described in the CMOP-E model and discussed in the background literature. If one is to consider the effectiveness of an intervention to improve a physical limitation such as ROM in the context of enabling a person to participate in occupations, it is important to consider the bi-directional nature of this type of impairment. In other words, if a burn survivor is functionally impaired by the elbow contracture which in turn affects the burn survivor’s mental health, the survivor’s mental health can then affect the

rehabilitation process and subsequently the outcomes of intervention such as reduced impairment. It is for this reason that the discussion begins with two studies that look at the impact of joint contracture and functional impairment due to burn injury.

5.3.1 Impact of Burn Injury

The first study under consideration was done by Pallua, Künsebeck and Noah (2003) out of Germany. They used a cross-sectional design to investigate factors influencing the QOL and social reintegration of 153 burn survivors. Findings showed that depression was related with increasing diminished function ($p<.05$). Depression as a possible impact of reduced function on burn survivors needs to be considered during the rehabilitation process for its possible influence on participating in rehabilitation intervention programs. The second study that speaks to the impact of the burn injury was done by a group of seven physicians in Turkey who investigated the impact of joint contracture on QOL after burn injury in 22 burn survivors at least six months post injury (Leblebici et al., 2006). The study used a prospective cohort design to compare QOL of a group of burn survivors with contractures to a group without. The SF-36 Health Survey, a widely used tool with proven psychometric properties, was employed to measure QOL including physical functioning, physical role limitations, social functioning and emotional role limitations. Findings showed that participants with contractures had significantly lower scores on the SF-36 subscales of physical functioning, role limitations and vitality ($p<.05, .01, .02$ respectively. The results of the two studies above remind the reader that burn survivors with elbow contractures related to burns are at higher risk for reduced QOL and subsequently are at risk for mental health disorders such as depression. Measures of mental health need to be included in any future studies related to splinting and serial casting.

Other factors that need to be considered are those that have been shown to impact rehabilitation interventions more directly. These fall under the categories of person or environment and include: body image dissatisfaction, coping strategies, choice, socioeconomic characteristics and social/emotional support. Referring again to the CMOP-E model, occupation is placed in context of the environment, occupation being the bridge between the person and the environment (Townsend & Polatajko, 2007). To the extent that occupation is influenced by both the environment and the person brings to mind the vision of a system that requires an adequate foundation on both sides to enable the bridge to function. The physical and affective components of the person as well as

the social environment need to be taken into account to enable a person to engage in occupation.

5.3.2 Personal Mitigating Factors

In the next paragraph, factors that fall under the category of person will be discussed. These include body image dissatisfaction, psychological distress, compliance and coping strategies. The results of four studies are presented here to demonstrate the influence of these factors on rehabilitation outcomes. The first study used a prospective cohort design to examine the impact of body image dissatisfaction on QOL after severe burn injury in 88 burn survivors (Fauerbach, et al., 2000). The SF-36 Health Survey was employed to measure QOL including physical functioning. Their findings showed body image dissatisfaction is significantly related to prolonged difficulties with mental and physical health-related QOL in those who have had a burn injury, even after controlling for pre-morbid QOL and injury severity. The second study under discussion received the 2004 Clinical Research Award from the American Burn Association (Fauerbach et al., 2005). It was a longitudinal prospective study undertaken to examine the effect of psychological burden on physical and psychosocial recovery in 162 burn survivors from three regional burn centers (Fauerbach et al., 2005). Results showed that greater in-hospital psychological distress was associated with greater physical and psychosocial impairment and role disruption even at six and 12 months after recovery. As well, the greater distress levels impeded the rate of recovery in physical and psychosocial function.

The third study, funded by The National Institute on Disability and Rehabilitation Research (NIDRR) in the US, was a descriptive study to review their comprehensive demographic and outcome database in order to evaluate the long-term sequelae of burn injuries (Klein et al., 2007). This study evaluated the relationship between coping strategies and burn injury characteristics, socio-demographics and long-term outcomes in 161 burn survivors. Of interest to the topic under review is the finding that alcohol and drug abuse are predictors for greater post-injury impairment and pre-injury level of function is a powerful indicator of return to school and work.

The fourth study under the person category was a descriptive study undertaken to determine if certain predictors (including compliance) influenced outcome variables (including ROM) (Sheffield et al., 1988). They examined the relationship between compliance with suggested plans of treatment and outcome and found a significant

relationship between non-compliance and the outcomes: limitations in ROM, and total days of care required (P<.01).

The four studies described above support the assumption that personal factors such as depression, body image dissatisfaction, coping strategies and compliance have an impact on intervention outcomes in burn survivors and need to be considered when evaluating research in this area.

5.3.3 Environmental Mitigating Factors

Social and physical environments shape occupational choice, influence health and well-being and structure options for social inclusion and exclusion (Townsend & Polatajko, 2007). Socioeconomic factors such as social support and financial resources fall under the category of environment. Although it was anticipated that there may be studies that examined the relationship between financial support and rehabilitation outcomes, none were found during the comprehensive search. However, the findings from six studies that addressed the influence of social support on the rehabilitation process were found and included as mitigating factors studies. In the first study, a phenomenological approach was used to gain an understanding of the experience of living with a major burn injury (Moi, Vindenes, & Gjengedal, 2008). The results of this study supported the importance of social support in their finding that significant others served as buffers, reducing obstacles and insecurities during the rehabilitation process.

The second study investigated health-related QOL in a large group of pediatric burn survivors to identify predictors of QOL and psychological adjustment (Landolt, Grubenmann, & Meuli, 2002). Results showed that a good family relationship was a significant predictor of good QOL. Family function needs to be assessed within the first few weeks of burn injury to ensure psychosocial interventions are offered immediately (Landolt et al., 2002).

The third study, a cross-sectional study, was carried out by a group in Korea looking at risk factors for psychosocial problems that prevent patients from developing appropriate adjustments after sustaining a burn injury. The results of the study reflected that social support including family support, gave patients the strength to endure the difficulties that they faced in the rehabilitation process (Park, Choi, Jang, & Oh, 2008). The fourth study, also using a cross-sectional design, investigated the relationship between social support and rehabilitation outcomes. Results showed that social support moderated the rehabilitation process independent of the severity of the burn injury

(Davidson, Bowden, Tholen, James, & Feller, 1981). Interestingly, the sources of social support created different patterns: family support being the most influential, friend support the second, and peer support the third.

The fifth study compared 52 children suffering from abuse-related scald burns and 50 non-abused scalded children, and found that compliance with rehabilitation follow-up was significantly worse in abuse-related scald burns (Hummel et al., 1993). The final study under the environment category was a cross-sectional study of 227 burn survivors to explore the relationships between coping strategies and outcomes (Kildal, Willebrand, Andersson, Gerdin, & Ekselius, 2005). The results showed that an avoidant coping strategy was most clearly related to poorer QOL scores whereas emotional support was the most beneficial strategy associated with higher QOL scores as measured with the Burn Specific Health Scale–Brief.

These six studies described under the environment category all have similar findings supporting the assumption that adequate social support has a positive effect on rehabilitation outcomes.

5.3.4 Client-centred Approach: Influence on Outcomes

A client-centred approach was identified by two studies as important factors that influence outcomes in interventions involving the application of orthoses or devices. The first study was a prospective correlational study carried out to identify predictor variables for assistive technology (AT) use in 204 clients (Wielandt, McKenna, Tooth, & Strong, 2006). The findings suggest that a client-centred approach which values clients' perceptions, opinions, and goals need to be considered to support the use of assistive technology. Although assistive technology in this study focused on devices (such as rails, bathing, toileting and dressing aids), similarities between orthotic devices and assistive technology devices can be drawn with respect to the intervention methods. The therapist generally prescribes an orthotic device or assistive device and therefore how one involves the client in this process is similar. The findings in the Wielandt et al. (2006) study showed choice and positive perceptions of characteristics of the AT were strongly related to AT use (Wielandt et al., 2006).

The second study demonstrated the importance of a client-centred approach for orthotic interventions using three client stories (McKee & Rivard, 2004). The client stories illustrated how collaboration with the client throughout the assessment and intervention process helps to optimize outcomes. The study recommends the use of a

functional outcome measure such as the Canadian Occupational Performance Measure COPM (Law et al., 1998b) "as an occupation-based consultation process that facilitates client-centred practice"(McKee & Rivard, 2004, p.307).

5.3.5 Mitigating Factors Summary

Orthotic interventions such as splinting and serial casting are designed to promote occupational performance in burn survivors with elbow contractures caused by a burn injury. The provision of splinting and serial casting interventions require the therapist to address the physical structures and functional factors that underlie the activity limitations and participation restrictions experienced by the burn survivor. The results of the studies discussed above also identify the need to consider the complete picture of the burn survivor, including their personal attributes, occupational and environmental demands when providing orthotic interventions. To exemplify the importance of considering mitigating factors, consider that a burn survivor may utilize an avoidant coping strategy which is considered an attempt to either avoid thinking about the stressor or to control the associated effect (Lawrence & Fauerbach, 2003). Not all avoidant strategies are necessarily linked to poorer outcomes, however, if the burn survivor chooses drug or alcohol use, this particular coping strategy has been linked to poorer outcomes (Klein et al., 2007).

Any future studies that investigate the effectiveness of specific rehabilitation interventions need to include tools such as the COPM (Law et al., 1998b), the Brief COPE (Carver, Scheier & Weintraub, 1989), the SF-36 (Ware & Sherbourne, 1992), and the BSHS-Brief (Munster, Horowitz & Tudahl, 1987) that provide a client-centred approach, determine coping strategies and measure QOL.

5.4 LIMITATIONS OF THE REVIEW

There is a possibility that key studies which fulfilled the inclusion criteria were missed if they used obscure words or words not included in the pre-established search terms. A diverse range of search terms were included in the search strategy to try to minimize this chance. As well, many databases were searched including those containing grey literature; and the bibliographies of included and excluded articles were searched. If abstracts were misleading, there is a chance of missing a key study; however, every effort was made to retrieve full articles in circumstances where the abstract was unclear. Key studies published in other languages may have been missed.

Sample heterogeneity, small sample sizes and selection bias made comparisons among the studies problematic. Experimental and quasi-experimental designs are not always possible due to ethical and practical reasons leaving alternate study designs that are subject to methodological criticisms as the mainstay of the review. Recognizing that there was a strong possibility that few RCTs would be found and that a well designed and executed study of alternate design may be more valuable, all designs were included.

Initially, PEDro scores were considered as a tool to help define the quality of studies based on well-accepted standards. Because of the tool's intended use for randomized trials, it had limited value in defining the quality across all the studies included in the review and was subsequently dropped from the process. Every effort was made to remain unbiased during the interpretation and integration process; however, working with results found in studies with methodological designs other than experimental introduced a risk of bias. A number of strategies were put into place to avoid biases resulting from the author's previous successful clinical experience with splinting and serial casting such as by employing a second reviewer, consultation with a third party and committee consultations. As a clinician with over 17 years of experience, six years in burn rehabilitation, the success of both splinting and serial casting interventions has been demonstrated repeatedly in individual cases of treating contractures in the clinical setting. As a member of an interdisciplinary team with different approaches to treating contractures, it is necessary to remain objective in examining the evidence so as not to inadvertently influence the findings to validate personal current practices.

Guidelines provided with the McMaster tools included information to assist the reviewer in deciding the quality of the study. These guidelines were useful for the appraiser to determine the quality of well-designed research studies. However, for those studies that had some, but not all of the positive attributes required in each category, the appraiser was required to use clinical judgement.

CHAPTER 6. CONCLUSIONS

The primary objective of this McMaster CLR is to determine if the methodological strength of the evidence for splinting and serial casting is such that these interventions can be considered effective for improving elbow contractures in burn survivors. In addition, an exploration of the evidence was undertaken to determine if there is any evidence to support one intervention over another or to warrant considerations of mitigating factors that may influence the effectiveness of splinting and serial casting.

The search strategy and number of studies reviewed provide enough information to address these questions and the analysis suggests patterns of research development that have occurred in this area of rehabilitation in order to make recommendations for future directions. The results from the included studies along with the arguments presented in the discussion section form the foundation for the following key conclusions and recommendations for practice and research. Following the key conclusions, implications for practice will be put forward.

6.1 KEY CONCLUSIONS

A total of six key conclusions were extracted from the 10 papers included in the review. Conclusions drawn from the papers are supported by data and illustrations from the publications and are presented below as they pertain to the objectives of the review. Conclusion one and two address the first question: Is the methodological strength of the evidence such that splinting and/or serial casting can be considered effective for improving elbow contractures in burn patients?

Conclusion 1. There is preliminary evidence to support splinting and serial casting as an effective treatment to reduce elbow contractures in burn survivors.

According to the physiological evidence, we can reason that the re-alignment of collagen, which affects soft tissue elasticity and elongation, can be manipulated by stretch. This stretch is achieved by employing orthotic interventions such as splinting and serial casting. Support for this conclusion begins to take form in the early studies of Larson et al. (1971) and Huang et al. (1978) both of which found that skeletal traction and static progressive splints improved contractures in the occupational performance component - ROM. Larson et al. (1971) used case studies to describe the early use and

success of traction and splints in their practice. Tissue biopsies from this early work illustrated how force and tension to counteract contracted soft tissues increases the length of the tissue.

Although biopsy results show physiological changes to support the biomechanical principle underpinning the use of stretch as an intervention, the strength of the evidence for splinting and serial casting was determined to be inconclusive because of the issues of validity and reliability of the primary outcome measure - ROM. Inconclusive meaning, there remains a need for more rigorous examination and testing.

In the same decade, Huang et al. (1978) used a large sample of 625 cases to demonstrate an inverse pattern of contracture incidence with splint use; incidence rates were cited as 81% with no splints, 70% with splint use less than six months, 33% with splint use for 6-12 months, and 19% for splint use longer than 12 months. These statistics provide an indication that there may be a relationship between splinting and contracture resolution in burn survivors, however, the evidence could not be considered conclusive due to the risk of intervention bias and problems with establishing reliability and validity for the outcome measures.

Another group of research reports addressed serial casting as a method to correct contractures in those burn survivors that were non-compliant with conventional splinting (Bennett et al., 1989; Johnson & Silverberg, 1995; Ridgway et al., 1991). Bennett's (1989) study used a prospective approach to evaluate the effectiveness of serial casting in four types of joints including the elbow, and found that serial casting increased ROM from 56% to 86% of normal (means). Results from the Ridgway et al. (1991) study demonstrated improvements of 40 degrees and 50 degrees ROM in plantarflexion contractures in a right and left ankle respectively with six days of serial casting. Similar improvements were found in the Silverberg and Johnson (1995) study with improvements of 45 degrees and 40 degrees in plantarflexion contractures in a right and left ankle respectively with two months of serial casting (Huang et al., 1978). Although the strength of the evidence from Bennett et al. (1989) and Ridgway et al. (1991) was ranked as inconclusive due to the problems with establishing reliability and validity in their outcomes, the Johnson and Silverberg (1995) study addressed these issues in their study to provide conclusive results. Case law could be an argument for establishing that the results indicate success in using serial casting, however, with the strength of only one study considered conclusive and two inconclusive, the evidence is only preliminary and requires further studies to replicate the findings using valid and reliable outcomes.

The dynamic splint first appeared in the literature in the mid-eighties as the focus of three studies, Richard (1986), Richard et al. (1995) and Richard et al. (2000). The two earlier studies were based on single cases that demonstrated large changes in ROM post dynamic splinting in relatively short periods of time: 50 degrees within 23 days in one and 55 degrees in 11 days in the other. Despite these obvious large differences post dynamic splinting, the evidence is considered inconclusive. With the high risk of selection bias in both studies and issues with data analysis in the 1995 study, the evidence was ranked as inconclusive and insufficient (respectively). The later study by Richard et al. (2000) was an exploratory cohort design with a larger sample that explored successful patient outcomes by comparing a group that used splinting and/or serial casting with a group that did not. Again the results demonstrated large changes in time to contracture resolution; however, issues with data reliability, validity and analysis resulted in ranking the evidence as insufficient. Also during this time period, splinting that utilized the principles of static progressive stretch was examined by Bonutti et al. (1994) using a retrospective approach. Although results were positive, the risk of selection bias was high and data analysis was insufficient to establish cause and effect or a correlation.

When considering the evidence in totality, there is an indication that this intervention may be effective as seen in the consistent positive results. However, the question is not fully resolved, doubts remain due to methodological issues and therefore the clinician must still rely on the evidence of clinical practice and expertise until further research with sound methodological quality can replicate these results. Although there is not yet sufficient evidence with overall methodological rigor to draw a firm conclusion, the research is promising, providing insight into the difficulties in carrying out rehabilitation outcomes research.

Conclusion 2. The length of time a splint (to provide prolonged stretch) is applied daily influences contracture resolution.

There was one study in this review that provided compelling evidence to support this theory. The Glasgow et al. (2003) study results showed faster contracture resolution with splints worn for between six and 12 hours daily than with splints worn for less than six hours daily. The sequential clinical trial design helped to decrease the risk of bias inherent in other designs. That detail along with valid, reliable outcome measures and appropriate data analysis resulted in ranking the quality of evidence as conclusive.

The relationship between amounts of time the intervention is applied and contracture resolution has been noticed in clinical situations evidenced by the attempts to explore the relationship in a number of the included studies (Bonutti et al., 1994; Huang et al. 1978; Richard et al., 1995; Richard et al., 2000). Although there were some methodological issues identified, the findings were positive. However, there is still a shortage of evidential support and additional, rigorously designed studies are required.

The third conclusion addresses the second question: Is there sufficient evidence to support the use of one type of orthotic over another?

Conclusion 3: The evidence was insufficient to support the use of one type of orthotic over another.

Efforts were made to compare the different types of splints in the Richard et al. (1995) study. Dynamic splinting was compared to a static splint. Due to the fundamental differences in the biomechanical principles guiding the use of these two types of splints, the results related to any comparison were disregarded and dynamic splinting was considered on its own merit. It may be more practical and meaningful if splints and serial casting were evaluated according to these underlying principles rather than by their individual features of convenience. In practice, serial casting is sometimes avoided due to the concerns about open wounds not healing; however, there was no evidence found to support this assumption and insufficient evidence to dispute it.

In the majority of the studies, cases were selected based on characteristics considered amenable to, or reasons for, choosing the intervention under study. This resulted in a high risk of selection bias and made it difficult to compare the success of one intervention with another. For example, age, compliance and social support were reasons for selecting serial casting as an intervention in the Ridgway et al. (1991) study.

Another source of confusion is the myriad of orthotic devices that may or may not use the same principles as each other and therefore begs the question, are we evaluating the same thing? Theoretical assumptions are that serial adjustments made to either casts or splints follow the principle of stress relaxation, whereas dynamic splints follow the principle of creep. Rather than focus on the type of device, future studies that focus on devices according to the principles of either creep or stress relaxation may provide a parameter for clinical decisions that has better validity.

The fourth conclusion addresses the third question: What evidence is there to warrant consideration of mitigating factors that may influence the effectiveness of splinting and serial casting?

Conclusion 4: There is a body of research to justify consideration of mitigating factors.

Generally, therapists make decisions on which type of intervention is the most appropriate based not just on the physical dysfunction to be corrected, but also in consideration of any mitigating factors present such as compliance and social support. The results of the 13 selected studies related to mitigating factors demonstrated that there are a number of mitigating factors that need to be considered when investigating the effectiveness of splinting and serial casting interventions. Factors that were found to influence rehabilitation interventions included body image dissatisfaction, coping strategies, choice, compliance, socioeconomic characteristics and social/emotional support. In addition, collaboration with a client through the assessment and intervention process helps to optimize outcomes (McKee & Rivard, 2004; Wielandt et al., 2006). Two measurement tools that are recommended as a result of these findings are the Canadian Occupational Performance Measure and the SF-36 Health Survey.

Several of the studies that were included in the evaluative critique did discuss a few of these mitigating factors as being influential, that of social support and compliance. In the Bennett et al. (1989) study, compliance with treatment regimes was reported as a reason for applying serial casting while in the Bonutti et al. (1994) study, compliance was reported as influential in the success of static progressive splinting. Ridgway et al. (1991) suggested that a child's contractures were associated with poor social support and the parent's non-compliance with stretching and the home program affected the outcomes.

Mitigating factors identified in the literature need to be included as outcome measures in order to find correlations to splinting effectiveness and before any studies can evaluate whether one type is more effective than another.

The next two conclusions are recommendations that came out of the study.

Conclusion 5: Further research needs to be undertaken using quality study designs that are amenable to the rehabilitation clinical setting employing standardized assessment tools that provide information on a wider range of outcomes.

The predominance of inconclusive and insufficient rankings for the 10 studies included suggests that additional research with study designs that employ methods such as randomization, larger sample sizes, blinding, and standardized tools and protocols, would fortify the evidence for splinting and serial casting. The relationships between contracture resolution and the various variables in the application of this type of intervention needs to be explored, such as timing, amount of force applied, personal and environmental factors. Larson et al. (1971) suggested investigating questions regarding intermittent versus continuous splinting while Richard et al. (2000) recommended using a series of consecutive patients, prospective designs, larger populations and reporting on overall outcomes.

Using common tools will allow comparison of results. To this end, Falder et al. (2009) developed a conceptual framework for unifying outcome measures with seven core domains of assessment and completed a clinical review of the commonly administered measurement tools. To encourage therapists to begin using consistent tools for future research in the area of splinting and serial casting in burn survivors, a list of recommended tools as suggested by Falder et al. (2009) can be found in Table I17, as well as Casting Guidelines, Tips and Techniques from the 1997 ABA Casting Workshop (Staley & Serghiou, 1998) in Appendix I: Resources. Included in the list of recommended tools are the resources to obtain the document and/or a copy wherever possible.

Conclusion 6: To improve the validity and reliability of the Critical Review Form – Quantitative Studies (Law et al., 2008), the author recommends further work be done to consider rating the key elements using categories, rather than nominal (yes/no) level measures, and to expand the guidelines to include information on minimal criteria needed to be considered adequate.

Although the inter-rater reliability has been determined to be quite high for the McMaster CLR forms, the skill and knowledge of the rater will obviously have an impact on that reliability. To extend the use of the forms to all interested reviewers at all levels

of experience and to ensure their continued reliability, it is recommended that the guidelines for the tool be expanded.

For example, when evaluating the quality of relevant background literature reviews that justify the study purpose, a yes/no answer is required. When evaluating the background literature section in the studies to judge their adequacy, the reviewers found variations of the amount and type of information in each study. One study synthesized the information from previous clinical work done in an area while another discussed the importance of the topic by expounding on the theoretical support. Gaps in knowledge were mentioned but not explicitly linked to the purpose of the study. At what point does the study deserve a no because it did not fulfill all the aspects of a good background literature review? Guidelines could be expanded to indicate minimal criteria to be considered adequate, or provide a scale that allows partial requirements to be acknowledged.

Methodological quality as it relates to generalizability could be expanded under clinical implications to ensure this element is not missed. Although generalizability can be determined from the study design, sampling methods and data analysis, it is not clearly delineated and could be missed. Generalizability, useful for determining the reliability or reproducibility of measurements under specific conditions, could be considered in terms of whether the specific results are expected in different circumstances or whether the results can be generalized beyond the specific group tested.

6.2 CLINICAL IMPLICATIONS

As pointed out by Law and McDermid (2008), the relevance of the results to clinical practice helps determine if the results of a study are important clinically. The results and conclusions in this integrative McMaster CLR are based on studies done with burn survivors with contractures related to burn injuries. The critical appraisal revealed the methodological strength of the evidence with mixed results. There is preliminary evidence to demonstrate that both splinting and serial casting are effective in resolving contractures, some evidence to demonstrate that duration of splinting and contracture resolution are related, insufficient evidence to demonstrate that one intervention type is better than another and there is a body of research that indicates consideration of mitigating factors is warranted.

Clinical decisions to use a splint or serial cast has been found to be varied among burn centers possibly due to the scarcity of well designed studies to provide definitive

parameters for their application (Richard et al., 2009; Richard, Staley, Miller, & Warden, 1997). Although, the exploratory research of the McMaster CLR discovered preliminary evidence of a relationship between splinting/serial casting interventions and contracture resolution, this relationship needs to be tested using experimental techniques to confirm that these interventions are the cause. Agreement that further research is needed is found in Richard et al. (2000) in their conclusion that their study provided preliminary direction for clinical decisions about the use of splinting and serial casting as treatment for burn scar contractures and recommended more research.

Current literature on evidence-based medicine suggests looking for the highest available evidence when making clinical decisions (Law & MacDermid, 2008). In terms of choosing the optimal rehabilitation program, the findings show that splinting and serial casting appear to be effective methods for reducing contractures. These results are encouraging for therapists utilizing these interventions in everyday practice and bring to light the need for valid and reliable outcome measurements to support efforts by researchers to pursue strong, conclusive evidence. Valid and reliable data is useful in both prospective and retrospective studies with a greater challenge in retrospective studies that rely heavily on clinicians' documentation practices. Retrospective data also provides valuable information on incidence and prevalence of various burn injury related outcomes needed for the development of baselines that outcomes can be compared to. The results and conclusions of this review provide compelling arguments for therapists to use the recommended evaluation tools when splinting or serial casting elbow contractures in burn survivors, a necessary step in evaluating rehabilitation outcomes for future research.

Researchers interested in this field can utilize the results of the results of this review as a springboard for future studies. Methods can be put in place to avoid the pitfalls discovered in working with the challenges related to researching outcomes in this population. For example, Richard et al. (2000) attempted to collect information on and evaluate factors that are thought to influence contractures related to burn injuries such as TBSA, age, compliance and different interventions and was hampered by selection, assembly and measurement bias. Possible solutions such as prospective designs, defining and adequately explaining constructs and grouping subjects according to characteristics may be tried and put into place during the initial stage of the research study (Garson, 2008). Because of the lack of blinding and informal sampling methods in all the studies except the Glasgow (2003) study, these studies were vulnerable to selection and assembly

bias. Subject selection based on successful outcomes will favour the use of an intervention and therefore unsuccessful cases need to be included in the research plan as well.

Also, research needs to include outcomes that measure mitigating factors identified in the research. Often, this type of evidence is found in qualitative or mixed methods studies. Given that the evidence relating to the use of splinting and serial casting is predominantly quantitative in nature and outcomes are focused on physical attributes, further research embracing both qualitative and quantitative paradigms needs to be pursued.

With respect to developing clinical practice guidelines, it is the recommendation of this integrative McMaster CLR that further research be conducted in this area prior to establishing formal clinical practice guidelines for the treatment of contractures in burn survivors with elbow contractures. Clinical practice guidelines should be based on strong evidence that provides clear and comprehensive recommendations. The following box provides a summary of the research recommendations that came out of this review.

Research Recommendations

- Corrective orthotic interventions be investigated as they relate to the biomechanical principles of creep and stress relaxation to explain soft tissue reaction to stretch.
- Consider mitigating factors such as social context and personal attributes that may influence the outcomes.
- Use and document standardized methods and tools for outcome measurement.
- Minimize the use of co-interventions in prospective studies.
- Utilize designs and methods that are conducive to inferential analysis.
- Extend follow-up period to include scar maturation timelines.

As a final note on clinical implication, it is important to keep in mind that despite what is found in the evidence, it is still important to keep in mind that the best course of action will vary from person to person because of personal or environmental factors and the status of benefits versus risks. The sequential plan findings from Glasgow et al. (2003) will not automatically lead to acceptance and widespread use of a new procedure. The sequential aspects of the trial concern treatment efficacy, but other issues such as

side effects, cost and use of resources will play a role in determining whether the new approach is to be adopted (Whitehead, 1997). Current philosophies of evidence-based medicine advocate that therapists need to consider not only the evidence found in the literature, but also the benefits and risks within the context of the survivor's personal values and expectations (Law & MacDermid, 2008; Straus, McAlister, Cook, Greenhaigh, & Guyatt, 2002).

6.3 SUMMARY STATEMENT

For years, professionals working in the burn field have provided splinting and serial casting as a treatment for elbow contractures resulting from a burn injury. This integrative McMaster CLR found preliminary evidence to support the use of splinting and serial casting for the treatment of contracted elbows resulting from burn scar contracture, with the caveat that further methodologically sound research is required for empirical validation of the intervention. Although therapists' clinical experience may find one treatment more effective than another, there remains insufficient evidence to determine when one type of intervention is more effective or appropriate than the other. There is research to justify considering other mitigating factors such as depression, body image dissatisfaction, coping strategies compliance, and social support when choosing and applying splinting and serial casting.

Occupational therapists working in burn centers will have better understanding of the empirical underpinnings of this intervention and be better equipped to inform individuals with elbow contractures and other health care providers of the proven and perceived benefits and risks associated with treatment. The line of reasoning for incorporating holistic, valid and reliable outcome measures provides motivation for positive change in current assessment and documentation practices.

Results of this study will be shared with other professionals working with burn survivors through presentations at the University of Alberta, the University of Alberta Hospital, the Canadian Association of Occupational Therapists annual conference, and the annual American Burn Association Conference. As well, efforts will be made to publish the study in the Canadian Journal of Occupational Therapy and the Journal of Burn Care and Rehabilitation.

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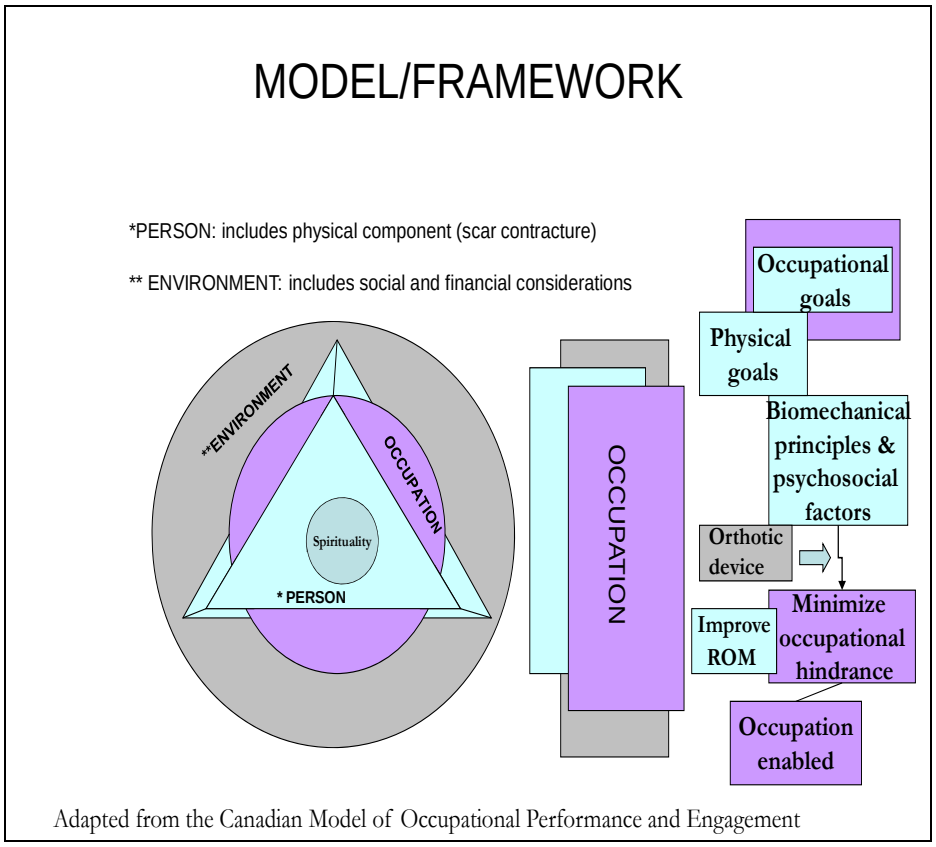
APPENDICES

Appendix A
Theoretical framework: CMOP-E Model/Framework



Note: The boxes on the right hand side of the model illustrate intervention process when providing an orthotic device such as a splint or a cast as it relates to the CMOP-E Model. This model framework portrays an occupational perspective used to guide occupational therapy. Adapted from "Canadian Model of Occupational Performance and Engagement (CMOP-E)" by E.A. Townsend and H.J. Polatajko in *Enabling Occupation II: Advancing an Occupational Therapy Vision of Health, Well-Being & Justice through Occupation.* P.23 Ottawa, On:CAOT Publications ACE.

Definitions: Occupation: "*groups of activities and tasks of everyday life, named, organized, and given value and meaning by individuals and a culture. Occupation is everything people do to occupy themselves, including looking after themselves (self-care), enjoying life (leisure) and contributing to the social and economic fabric of their communities (productivity)"*(Townsend & Polatajko, 2007).**Spirituality:** *"sensitivity to the presence of spirit"*(McColl, 2000) a pervasive life force, source of will and self-determination, the shared force that animates all living things (Townsend & Polatajko, 2007).

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Appendix B
Properties of Normal Skin and Burn Scar

Wound Healing

The formation of scar tissue is the natural process in wound healing that involves re-epithelialization, collagen deposition, and centripetal movement of the wound edges to reduce the defect (Spence & Ware, 2006; Tredget et al., 2006). Scar tissue is typically minimal when the wound margins are well approximated; however, in larger wounds such as burns, the formation of scar tissue has a tendency to be excessive. In burns, a number of factors influence the amount of scar tissue that is formed including depth, healing time, and presence of infection (Tredget et al., 2006). The deeper the burn and longer it takes to heal, the higher the risk of scarring. Scar tissue that becomes raised, reddened, and rigid is referred to as hypertrophic scarring. It is assumed that collagen abnormalities contribute to this sequelae (Tredget et al., 2006). Skin pliability is reduced as the scar thickens and becomes inelastic. As a result of this loss of pliability, the movement of structures underlying the skin is also affected.

Contracture

Contracture (R. Richard & Staley, 1994; Spence & Ware, 2006) is the term given to burn wounds that develop excess scar over areas of joints and mobile anatomic structures with resulting dysfunction and deformity. These results often have implications on occupational performance due to the restrictions on normal joint movements. In the case of scarring that traverses the antecubital fossa, the person is prevented from obtaining full elbow extension thus affecting the ability to do activities such as reaching a high shelf, carrying groceries, or playing racquet sports. In cases where scarring occurs on the posterior elbow, flexion is hindered affecting activities such as brushing teeth, operating machinery, and hugging a loved one.

Bio-physiological Properties

An understanding of the bio-physiological properties of skin and scar tissue sheds light on the theory behind the application and timing of the splint or

cast. Intact skin is composed of a fibrous network of collagen and elastin fibers surrounded by lubricative ground substance (Richard & Staley, 1994). In response to the burn injury and the wound healing process, very little elastin is regenerated and the amount of collagen is increased. The collagen in normal skin is arranged in a wavy pattern with ample interstitial space, while in scars it is arranged in a tightly woven whorl-like pattern resulting in thickened skin with a loss in pliability. It has been postulated that serial splinting and serial casting forces the jumbled elastin and collagen fibers to elongate and re-align in a more linear pattern by applying a prolonged stretch to these tissues. With treatment, the predicted progression towards a more natural state for skin is marked by three phases. It is believed that when stretch is first applied to the scar, the elastic fibers elongate and the collagen fibers begin to uncoil (Nordin & Frankel, 1989). The elongation is often referred to as strain. This phase claims the greatest change in length and requires only a low load (<100gm/cm width) to stretch the fibers. According to Nordin (1989), the second phase requires an increased force to promote the re-alignment of collagen fibers as the elastin fibers have already been stretched out and the ground substance which is found in the interstitial spaces has to be "squeezed out". Nordin goes on to explain that in the third phase, a significant amount of force is required for further re-alignment as the majority of the coils have already unwound. These suppositions are manifested clinically as the series of cast and splint applications progress; most gains are seen in the first few splinting or casting treatments.

Another important concept to consider is that of hysteresis or "lagging behind". Once the load (stress) is reduced, the tissue begins to return to its previous length but not all the way. This is especially true in phase I due to the elastin factor and higher percentage of collagen whorls. Richard and Staley (1994) state that it takes approximately 6-10 cycles of successive length induction to maximize tissue elongation with a low load. After that, a higher load is required to induce **"**creep**",** the progressive elongation of the tissue (Richard & Staley, 1994). Gradually less force is required to keep the tissue extended at a given length, a term called **"**stress relaxation**"**.

Appendix C
Critical Review Guidelines

Critical Review Form Guidelines – Quantitative Studies

Critical Review Form Guidelines – Qualitative Studies

Guidelines and forms can be accessed at:

http://www.srs-mcmaster.ca/Default.aspx?tabid=630

Appendix D
Search Tables

Table D1
Websites Searched for Guidelines

Website	URL
National Guideline Clearinghouse (US)	http://www.guideline.gov
Clinical Practice Guidelines from the Canadian Medical Association (CAN)	http://mdm.ca/cpgsnew/cpgs/index.asp
the National Institute of Clinical Excellence Guidelines (UK)	http://www.nice.org.uk
Burn Engine	http://www.repar.veille.qc.ca/burnengine
Burn Therapist	http://www.burntherapist.com
Evidence Based Occupational Therapy	http://www.otevidence.info
EBP Guidelines for Rehabilitation	http://www.health.uottawa.ca/rehabguidelines/en/login.php
National Health and Medical Research Council (Australia)	http://nhmrc.gov.au
New Zealand Guidelines Group	http://www.nzgg.org.nz
Scottish Intercollegiate Guidelines Network	http://www.sign.ac.uk

Table D2
Search Terms, Subject Headings and Keywords

Concepts	MeSH terms	Other key terms*
Elbow contractures	Contracture	Contracture**
Scarring	Cicatrix	Scar**
		Hypertrophic
		Cicatrix
Burns	Burns	Burn**
		Thermal injury
		Chemical burn
		Electrical burn
Serial casting	Casts, surgical	Serial cast**
		Surgical cast**
Splinting	Orthotic devices	Splint**
		Brac*
		Orthotic**
		Appliance
		Static splint**
		Progressive static splint**
		Dynamic splint**
		Assistive Device**
		Assistive Technology
Progressive stretch	Stress, mechanical	Mechanical stress
		Progressive Stretch
		Stretch
		Load
Range of motion	Range of motion, articular	Range of motion
		Mobility
		Movement
		Physiological properties
Function	Activities of daily living	Activities of daily living
		Function
	Biomechanics	Biomechanic**
	Task Analysis & performance	Occupational performance
Personal factors:	Patient satisfaction	Patient satisfaction
	Quality of life	Client/consumer satisfaction
		Patient well-being
		Body Image Satisfaction***
		Psychological distress***
		Coping strategies***
		Factors predicting use
Environmental factors	Socioeconomic factors	Socioeconomic
		Social conditions
		Social support***
		Financial support***
	Social perception	Stigma

Note: * (Subject headings, synonyms, text words, variations) **Truncation symbol appropriate for each database. ** *Words added in final stage of review

Table D3
Search Record Summary

Database/Resource	Interface	Years Searched	# Screened	Included	Date Searched	Table
		Peer Reviewed Literature				
EBMR	OVID	1963-2010	5	0	Jan.24/10	D4
Medline	OVID	1963-2010	80	8	Jan.13/10	D4
EMBASE	OVID	1980-2010	29	1	Jan.24/10	D5
CINAHL	EBSCO	1963-2010	16	0	Jan.30/10	D5
PsycINFO	OVID	1963-2010	50	0	Jan.24/10	D5
PEDro	EBSCO	1963-2010	2	0	Jan.31/10	D6
OTSeeker	EBSCO	1963-2010	5	0	Jan.31/10	D6
OTDBase	OVID	1970-2010	3	0	Feb.15/10	D6
RehabDATA	NARIC	1963-2010	8	0	Feb.17/10	D6
CIRRIE	CIRRIE	1990-2010	3	0	Feb.18/10	D6
Reference lists	Hand search		49	0	Mar.13-14/10	
JBCR	Hand search	2005-2010	14	0	Feb.19/10	
		Grey Literature				
ABA Conf proceedings	ABA Website	2006-2010	10	0	Mar.2-6/10	
Conf proceedings-Annual Canadian Interest Group	UAH Burn Research Office hand search	2003-2009	1	0	Aug.31/09	
Conf proceedings other	UofA Libraries Website	1963-2010	8	0	Feb.24/10	
OCLC Papers First	OCLC	1993-2010	8	0	Feb.21/10	
Conference Papers Index	CSA Illumina	1982-2010	4	0	Feb.18/10	Table D7
OCLC Proceedings First	OCLC	1993-2010	0	0	Mar.3/10	
Proquest Dissertations & Theses	Proquest	1963-2010	1	0	Mar.17/10	
OpenSIGLE	OpenSIGLE	1963-2010	0	0	Mar.17/10	
OCLC WorldCat	OCLC	1963-2010	0	0	Mar.17/10	
SCOPUS	Scopus	1963-2010	23	1	Mar.24/10	Table D7
Google Scholar	Google Scholar	1963-2010	1	0	Mar.24/10	
Web of Science	ISI Web of Knowledge	2000-2010	18	0	Mar.24/10	
Reference Lists: Texts	Hand search		4 texts*	0	Mar.25/10	

Note: * Texts include: Total Burn Care 2nd edition (2002); Hand Splinting-Principles & Methods (1987); Burn Care & Rehab: Principles & Practice (1994) ;Achauer and Sood's Burn Surgery: Reconstruction & Rehabilitation (2006)

Table D4
Search Record EBMR & Medline Databases

Evidence Based Medicine Reviews (EBMR) Database

Concept	Cicatrix	Burns	Articular	Mechanical/ Biomechanics	Task analysis & performance	Surgical/ Orthotic devices	Pt.satisfaction/ Social perception	Economic factors	Hits	For further screen
# hits	758	516	1466	518	4320	724	4617	54		
(AND)	x	x	x	x					7	0
(AND)	x	x			x				44	0
(AND)	x	x				x			11	2
(AND)	x	x					x		57	0
(AND)	x	x						x	0	0
(AND)	x		x		x	x			48	3
(AND)		x			x		x		133	0
(AND)		x						x	1	0
(AND)			x	x		x			49	0
(AND)			x		x	x	x		125	0
(AND)						x		x	0	0
Note: Interface= OVID								**Total:**	**302**	**5**

Search Record MedlineDatabase

Concept	Contracture Cicatrix	Burns	ROM articular	Stress Mechanical/ Biomechanics	ADL's/ Task analysis & performance	Casts, surgical/ orthotic devices	QOL/PT satisfaction/ social perception	Socio-economic factors	Hits	Selected for further screen
# hits	116284	67096	323078	171952	1157017	94776	183690	93880		
(AND)	x	x	x	x					11	2
(AND)	x	x			x				223	13
(AND)	x	x				x			219	24
(AND)	x	x					x		87	11
(AND)	x	x						x	11	1
(AND)	x		x		x	x			114	5
(AND)		x			x		x		117	7
(AND)		x						x	339	8
(AND)			x	x		x			268	7
(AND)			x		x	x	x		90	1
(AND)						x		x	163	1
Note: Interface= Ovid								**Total:**	**1642**	**80**

Appendix D. Search Tables

Table D5
Search Record EMBASE, CINAHL and PsychINFO Databases

	Concept	Contracture/ Cicatrix	Burns	ROM articular	Stress, Mechanical/ Biomechanics	ADL's/Task analysis & performance	Casts, Surgical/ Orthotic devices	QOL/Pt satisfaction/ Social perception	Socio-economic factors	#Hits	Selected for further screen
EMBASE Database	(AND)	x	x	x	x					9	1
	(AND)	x	x			x				371	9
	(AND)	x	x				x			224	6
	(AND)	x	x					x		155	2
	(AND)	x	x						x	3	0
	(AND)	x		x		x	x			158	3
	(AND)		x			x		x		135	4
	(AND)		x						x	23	0
	(AND)			x	x		x			581	3
	(AND)			x		x	x	x		104	2
	(AND)						x		x	17	0
	Total:									**1780**	**30**
CINAHL Database	(AND)	x	x	x	x					1	1
	(AND)	x	x			x				54	4
	(AND)	x	x				x			56	3
	(AND)	x	x					x		28	2
	(AND)	x	x						x	2	0
	(AND)	x		x		x	x			32	0
	(AND)		x			x		x		38	1
	(AND)		x						x	116	4
	(AND)			x	x		x			102	1
	(AND)			x		x	x	x		18	0
	(AND)						x		x	20	0
	Total:									**467**	**16**
PsychINFO	(AND)	x	x			x				5	
	(AND)	x	x				x			4	
	(AND)	x	x					x		5	
	(AND)	x	x						x	1	
	(AND)	x		x		x	x			4	
	(AND)		x			x		x		13	
	(AND)		x						x	8	
	(AND)			x	x		x			11	
	AND)			x		x	x	x		10	
	AND)						x		x	3	
	Total:									**64**	**5**

Note: Interface = OVID (EMBASE), EBSCO Host (CINAHL), OVID (PsychINFO)

Table D6

Search Record Rehabilitation Databases

Concept	PEDro		OT Seeker		OTD Base		RehabData		CIRRIE	
	Hits	Further screen	Hits	Further screen	Hits	Further screen	Hits	Further screen	Hits	Further screen
Contracture/ Cicatrix	59	1	6	0	25	0				
Burns	345	1	57	3	8	0	362	5	79	3
ROM articular	2	0	10	0			66	0		
Stress, Mechanical	10	0	0	0						
Biomechanic*	79	0			34	0	250	0		
ADL's/Task analysis & performance	1	0	11	0	285	1				
Casts Surgical/splint*/	121	0	79	2	57	2	45	0		
Daily Living and functional stats									284	0
Daily Living and Adjustment									203	0
Attitudinal Barriers									1	0
Orthotic devices									20	0
Bioengineering and motor skills									53	0
QOL/ Pt satisfaction/ Social perception	0	0	3	0						
Body Image							122	2		
Personal adjustment							14	0		
Socio-economic Factors/social adjustment	0	0	1	0						
Clinical trials/Evidence based practice					175	0	416	0		
Functional status							25	**0**		
Social Adjustment							25	**0**		
TOTALS:	**617**	**2**	**167**	**5**	**584**	**3**	**1325**	**8**	**640**	**5**

Note: Interface= EBSCO Host/EBSCO Host/ OVID/NARIC /CIRRIE respectively

Table D7
Search Record CPI and Scopus

Concept	Contracture/ Cicatrix	Burns	ROM articular	Stress, Mechanical/ Biomechanics	ADL's/ Task analysis & performance	Casts, Surgical/ Orthotic devices	QOL/ Pt satisfaction/ Social perception	Socio-economic factors	#Hits	Selected for further screen
Conference Papers Index (CPI)										
(AND)	x	x							10	2
(AND)		x				x			4	0
(AND)	x		x						1	0
(AND)		x			x				299	2
(AND)						x		x	0	0
(AND)			x	x					45	0
(AND)			x		x				317	0
(AND)			x			x			8	0
(AND)							x		385	0
Total:									**1069**	**4**
Database: Scopus										
(AND)	x	x	x	x						8
(AND)	x	x			x					8
(AND)	x	x				x				1
(AND)	x	x					x			1
(AND)	x	x						x		1
(AND)	x		x		x	x				1
(AND)						x	x			0
(AND)		x				x				0
(AND)			x	x		x				1
(AND)			x		x	x	x			2
(AND)						x		x		0
Total:										**23**

Note: Interface = CSA Illumina(CPI), Scopus (Scopus)

Table D8
Inclusion/Exclusion Criteria

Inclusion/exclusion criteria	Justification
Any outcome measures related to occupational performance, well-being and satisfaction with regard to splinting or casting (included).	A broad approach is taken anticipating that there will be a scarcity of literature.
Qualitative and quantitative outcome studies (included).	Broad spectrum of methods included to encompass all variables that may lead to understanding and explaining the problem under consideration.
Inpatients and outpatients of all ages (included).	All ages are included to obtain a wide a range of subjects as possible.
Burn injuries and/or scar contractures affecting any joints (included)	Studies that include any joint(s) are included to capture studies that look at the effect of prolonged stretch on contracted skin over a joint
Contractures resulting exclusively from neurological or orthopedic conditions (excluded).	Contractures related exclusively to neurological and orthopedic conditions are not included due to the difference in the underlying disease process. These conditions may be chronic in nature; the underlying factors that contribute to the contracture may never resolve. Studies which include soft tissue injuries with the above conditions are not excluded.
Publication dates 1963 to present (included).	Dates are based on the timeframe that includes the date splinting/serial casting is cited in the literature as first tried as treatment.

Table D9
Mitigating Factors Articles

Authors (Year of Publication) /Location in document	Title Source	Findings Conclusions
Davidson, T. N., Bowden, M. L., Tholen, D., James, M. H., & Feller, I. (1981)/4.4.3	Social support and post-burn adjustment. *Arch Phys Med Rehabil, 62*, 274-278.	Social support moderates the rehab process independent of burn severity, Is related to QOL & participation in activities.
Fauerbach, J. A., Heinberg, L. J., Lawrence, J. W., Munster, A. M., Palombo, D. A., Richter, D., et al. (2000)/4.4.2	Effect of early body image dissatisfaction on subsequent psychological and physical adjustment after disfiguring injury.*Psychosomatic Medicine, 62*(4), 576-582.	Body image dissatisfaction affects QOL. Distress moderates impact on aspects of physical health.
Fauerbach, J. A., Lezotte, D., Hills, R. A., Cromes, G. F., Kowalske, K., deLateur, B. J., et al. (2005)/4.4.2	Burden of burn: A norm-based inquiry into the influence of burn size and distress on recovery of physical and psychosocial function. *JBCR, 26*(1), 21-32.	Physical and psychosocial functioning more impaired, rate of recovery slower among those with either large physical or psychological burden.
Hummel, R. P., Greenhalgh, D. G., Barthel, P. P., DeSerna, C. M., Gottschlich, M. M., James, L. E., et al. (1993)/4.4.3	Outcome and socioeconomic aspects of suspected child abuse scald burns. *JBCR, 14*(1), 121-126.	Compliance with discharge rehabilitation program was significantly lower in children from homes with poorer socioeconomic characteristics and suspect for abuse.
Leblebici, B., Adam, M., Bagis, S., Tarim, A. M., Noyan, T., Akman, M. N., et al. (2006)4.4.1	Quality of life after burn injury: The impact of joint contracture. *JBCR, 27*(6), 864-868.	Joint contracture impacts QOL, physical functioning, physical role limitations and vitality.
Kildal, M., Willebrand, M., Andersson, G., Gerdin, B., & Ekselius, L. (2005)/4.4.3	Coping strategies, injury characteristics and long-term outcome after burn injury. *Int Journal Care Injured, 36*, 511-518.	An avoidant strategy was related to work status, marital status and living conditions and was related to poor outcomes on BSHS-B.

Table D9. *Mitigating Factors Articles (cont'd)*

Authors (Year of Publication) /Location in document	Title Source	Findings Conclusions
Klein, M. B., Lezotte, D. L., Fauerbach, J. A., Herndon, D. N., Kowalske, K. J., Carrougher, G. J., et al. (2007)/4.4.2	The national institute on disability and rehabilitation research burn model system database: A tool for multicenter study of the outcome of burn injury. *JBCR, 28*(1), 84-96.	Pre-injury level of function is one of the powerful indicators of successful return to school and work. Alcohol and drug abuse predictor for greater post injury impairment.
Landolt, M. A., Grubenmann, S., & Meuli, M. (2002)/4.4.3	Family impact greatest: Predictors of quality of life and psychological adjustment in pediatric burn survivors. *The Journal of Trauma, 53*(6), 1146-1151.	Good family relationships – significant predictor of good QOL..
McKee, P., & Rivard, A. (2004)/4.4.4	Orthoses as enablers of occupation: Client-centred splinting for better outcomes. *Canadian Journal of Occupational Therapy, 71*(5), 306-313.	Qualitative study – iterative collaboration and follow-up influence goal achievement.
Moi, A. L., Vindenes, H. A., & Gjengedal, E. (2008)/4.4.3	The experience of life after burn injury: A new bodily awareness. *Journal of Advanced Nursing, 64*(3), 278-286.	Qualitative study – New bodily sensations/awareness interfere with daily activities. Significant others reduce obstacles in all aspects.
Pallua, N., Künsebeck, H., & Noah, E. M. (2003)/4.4.1	Psychosocial adjustments 5 years after burn injury. *Burns, 29*(2), 143-152.	Physical function best predictor for QOL, social reintegration, and participation in activities.
Park, S., Choi, K., Jang, Y., & Oh, S. (2008)/4.4.3	The risk factors of psychosocial problems for burn patients. *Burns, 34*(1), 24-31.	Lack of family support and living expenses – significant factors in rehabilitation problems.
Sheffield, C. G., Irons, G. B., Mucha, P., Malec, J. F., Ilstrup, D. M., & Stonnington, H. H. (1988)/4.4.2	Physical and psychological outcome after burns. *JBCR, 9*(2), 172-177.	Non-compliance influences the outcome variables ROM and quality of life.
Wielandt, T., McKenna, K., Tooth, L., & Strong, J. (2006)/4.4.4	Factors that predict the post-discharge use of recommended assistive technology. *Disability and Rehabilitation: Assistive Technology, 1*, 29-40.	Lack of consideration of clients' preferences during selection process for assistive technology is strongly related to its non-use.

Table D10
Accepted Articles

Authors	Title	Year
Bennett, G. B., Helm, P., Purdue, G. F., & Hunt, J. L.	Serial casting: A method for treating burn contractures.	1989
Bonutti, P. M., Windau, J. E., Ables, B. A., & Miller, B. G.	Static progressive stretch to re-establish elbow range of motion	1994
Glasgow, C., Wilton, J., & Tooth, L.	Optimal daily total end range time for contracture: resolution in hand splinting.	2003
Huang, T. T., Blackwell, S. J., & Lewis, S. R.	Ten years of experience managing patients with bun contractures of axilla, elbow, wrist and knee joints	1978
Johnson, J., & Silverberg, R.	Serial casting of the lower extremity to correct contractures during the acute phase of burn care	1995
Larson, D. L., Abston, S., Evans, E. B., Dobkovsky, M., & Linares, H. A.	Techniques for decreasing scar formation and contractures in the burned patient.	1971
Richard, R. L.	Use of the Dynasplint to correct elbow flexion burn contractures: A case report	1986
Richard, R., Miller, S., Staley, M., & Johnson, R. M.	Multimodal versus progressive treatment techniques to correct burn scar contractures.	2000
Richard, R., Shanesy, C. I., & Miller, S. F.	Dynamic versus static splints: a prospective case for sustained stress.	1995
Ridgway, C. L., Daugherty, M. B., & Warden, G. D.	Serial casting as a technique to correct burn scar contractures	1991

Appendix E

Consultations

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Appendix F

Figures

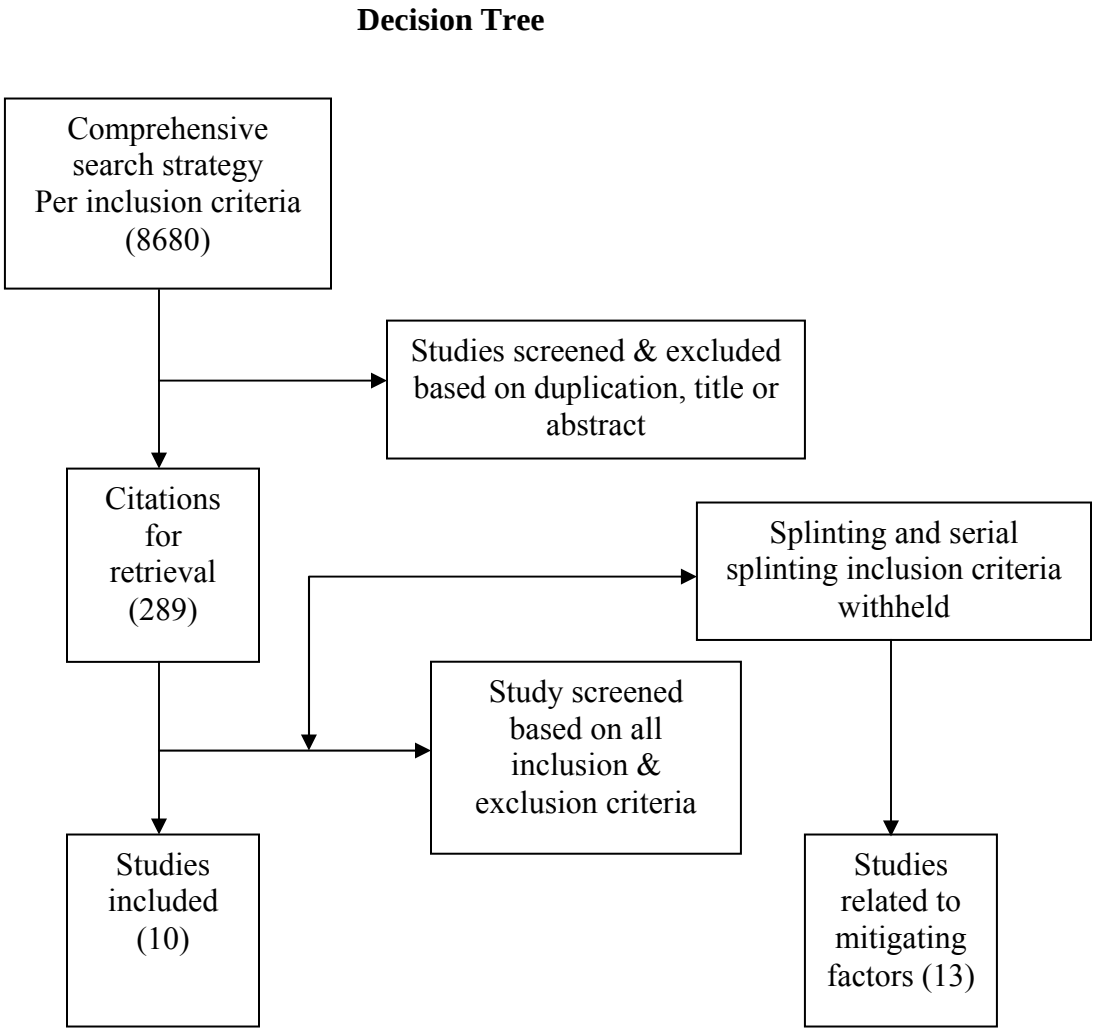
Figure 1. Decision Tree

Figure 2. Conceptual Framework

Figure 3. Computation of Phi Coefficient

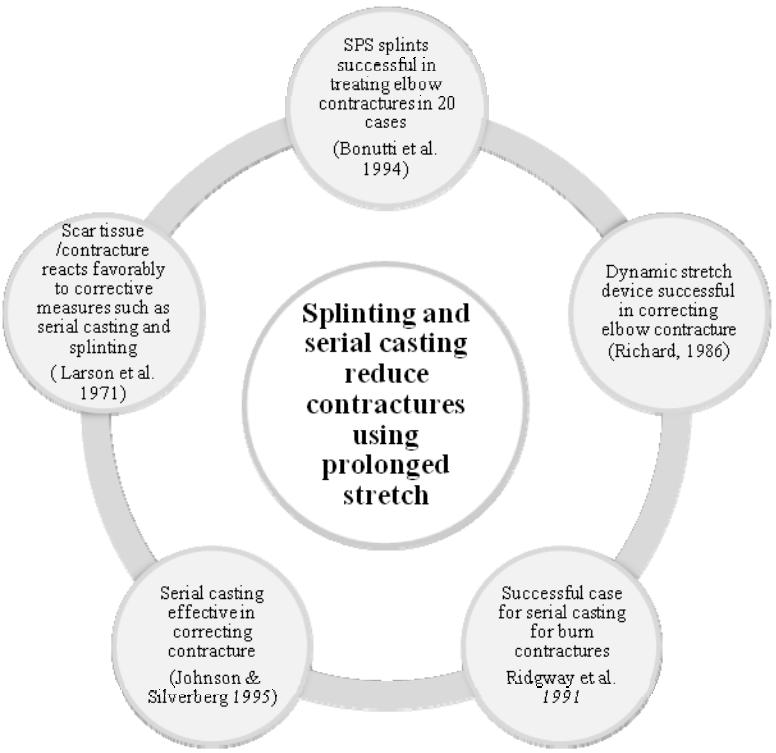
Figure F1

Decision Tree



Note: The above figure provides the decision trail used in searching and selecting the studies that were included in the McMaster CLR.

Figure F2
Conceptual Framework



Note: Each sphere on the outer circle represent an individual study that has been included in this McMaster CLR. The center sphere represents the theory/idea that is supported by each of the outer spheres to form what is called "Case Law" by Portney and Watkins (2000).

Figure F3

Computation of Phi Coefficient

Computation of Phi Coefficient (□) using a Contingency Table

		Contractures		Totals
		Yes	No	
Splinting/ Pressure	Yes	288 (A)	501 (B)	789 (A+B)
	No	370 (C)	76 (D)	446 (C+D)
Totals		658 (A+C)	577 (B+D)	1235

□= (501)(370) – (288)(75)/√(789)(446)(658)(577) =

= (185370)-(21600)/365516 = .448

Appendix G

Completed Critical Review Forms

Copies of the following completed critical review forms can be obtained from the author on written request.

Bennett et al.(1989)	Serial Casting: A Method for Treating Burn Contractures
Bonutti et al.(1994)	Static Progressive Stretch to Reestablish Elbow Range of Motion
Glasgow et al.(2003)	Optimal Daily Total End Range Time for Contracture: Resolution in Hand Splinting
Huang et al.(1978)	Ten Years of Experience in Managing Patients with Burns Contracture of Axilla, Elbow, Wrist, and Knee Joints
Johnson & Silverberg (1995)	Serial Casting of the Lower Extremity to Correct Contractures During the Acute Phase of Burn Care
Larson et al.(1971)	Techniques for Decreasing Scar Formation and Contractures in the Burned Patient
Richard (1986)	Use of the Dynasplint™ to Correct Elbow Flexion Burn Contracture: A Case Report
Richard et al.(2000)	Multimodal Versus Progressive Techniques to Correct Burn Scar Contractures
Richard et al. (1995)	Dynamic Versus Static Splints: A Prospective Case for Sustained Stress
Ridgway et al.(1991)	Serial Casting as a Technique to Correct Burn Scar Contractures: A Case Report

Appendix H

Summary Tables

Table H11. Descriptive Summary of Quantitative Studies

Table H12: Summary of Reported Findings

Table H13. Health Indicator Findings

Table H14. Evidence Table

Table H15. Risk of Bias

Table H16. Study Relevance Factors

Table H11
Descriptive Summary of Quantitative Studies

Author & Date	Purpose/ Hypothesis	Design/ Method	Sample size	*Participant Characteristics	Intervention	Outcomes	Results
1989 Bennett et. al.	To evaluate the effectiveness of serial casting on burn contractures	Before and after design (prospective)	N=15 (35 joints)	Burn TBSA large X gender, age & setting	Serial casting	Δ % NROM □	↑% NROM □ Wounds healed
1994 Bonutti et. al.	To evaluate a progressive stretch protocol for elbow contractures	Before and after case series (retro)	N=20	Trauma X gender, adults Outpt. setting	Splint -SPS	Δ ROM □ Pain Satisfaction	↑ROM No skin tears
2003 Glasgow et.al.	To explore the relationship between daily total end range time and contracture resolution	Sequential Clinical Trial (prospective)	N=32 (16 pairs)	Trauma X X gender, adult Outpt. setting	Dynamic/ static splints	ROM Δ >20 □	Splint use 6-12 hrs. more efficient than <6 hrs.
1978 Huang et.al.	To evaluate efficacy of splints/pressure on burn scars across major joints	Case Control (retro)	N=625	Burn X setting	Splint-SPS	% of ROM Surgical release	↓#contractures with ↑splint use Fewer surgeries
1995 Johnson & Silverberg	To demonstrate effectiveness in correcting contracture & allowing wound healing in burn contracture	Case study (retro)	N=1	Burn: TBSA large M. gender, Ped. Inpt setting	Serial casting	ΔROM □ Wound healing Ambulation	↑ROM: Healed ↑Independence in ambulation
1971 Larson et.al.	To demonstrate the effect of skeletal traction/pressure/ splints on early HTS properties	Case studies (retro)	N=5	Burn TBSA large X gender, peds Inpt setting	Splints/ Pressure Skeletal traction	Contracture resolution Collagen state.	↓Contractures Fiber alignment
1986 Richard R.	To describe the success of Dynasplint™ to correct elbow contractures	Case study (retro)	N=1	Burn TBSA large M. gender,adult Inpt. Setting	Dynamic splint	Δ ROM □	Contracture resolved
2000 Richard et.al.	To investigate successful pt. outcomes of scar contracture resolution in burn pts.	Observational longitudinal Cohort (retro)	N=52	Burn:TBSA large X gender & age	Splints/Serial casting versus Massage/Ex. /Pressure	Contracture resolution	↓ days to correct contracture with splints/serial casting
1995 Richard et.al.	To demonstrate superiority of a dynamic elbow extension splint over a static splint for elbow contractures in burn pts.	Single case (retro)	N=1	Burn TBSA large F. gender, adult Inpt. Setting	Dynamic & static splint	Δ ROM □	↑ROM □ Dynamic splint ↓ROM static splint
1991 Ridgway et.al.	To present a successful case for using serial casting to correct burn contractures	Case study (Retro)	N=1	Burn TBSA large M. gender, ped. Inpt. Setting	Serial casting	ROM □ Ambulation	↑ROM □ ↑Independence in ambulation

Δ = change; □ = degrees; Tx.= treatment; NROM – Normal ROM; Gender: Adult=A, Female=F Male =M, Mixed=X

Table H12
Summary of Reported Findings

	Author & Date	Bennett et al. 1989	Bonutti et.al., 1994	Glasgow et.al., 2003	Huang et.al., 1978	Johnson & Silverberg 1995	Larson et.al., 1971	Richard R., 1986	Richard et.al., 2000	Richard et.al., 1995	Ridgway et al. 1991
	Intervention	Serial Casting	SPS splint	Dynamic splint SPS splint	Various splints SPS splint	Serial Casting	Traction Splints Pressure	Dynamic splinting	Splinting Casts	Dynamic Splinting Static splint	Serial Casting
	Principle	Creep	Stress relaxation	Creep Stress relaxation	Stress relaxation	Creep	Creep Stress relaxation	Creep	Creep	Creep Stress relaxation	Creep
Primary outcomes	ROM Δ (Contracture resolution)	Significant ↑ROM (% normal ROM)	↑ROM in flex & ext	↓Contracture faster with splint use 6-12 hrs./day	Incidence contractures ↓ with ↑splint use: Duration appeared to play a role	↑ROM post serial casting	↓Contractures post traction/splints/pressure	↓Contracture post dynamic splinting	↓Contractures faster with splints/casts compared to other approaches	↓Contracture post dynamic splinting	↑ROM post serial casting
	Movement related functions Ability to carry out ADLs					↑indep in ambulation				ADL's may ↑ contractures	↑indep in ambulation
Secondary outcomes	Integumentary Δ	Wounds continued to heal	No skin tears		Open sores reported as one reason for drop-outs	Open areas healed in serial casts	Collagen alignment post 2 wks.of traction & at 40 day f/u				
	Pt./survivor Satisfactions Engagement in Occupational role		No drop outs								
	Adverse effects		Discomfort	Pain	Pain/ discomfort reported as reasons for drop-outs	Skin irritation r/t silicone insert under cast	Ischemia (traction) Maceration/ ulceration (splints)	None reported	None reported	Moderate edema after 5 days of dynamic splinting. Resolved.	Excoriation

Key: Δ = change; ADL;s=activities of daily living; ROM=range of motion;indep.=independence; r/t=related to; pt. =patient;f/u=follow up

Table H13
Health Indicator Findings

Author & Date	Economic Circumstances		Income Security		Social Circumstances		Addictions		Level of
	Housing	transportation	Employment	Other	Social support	relations	Drug	Alcohol	Education
Bennett et.al.1989	n/c	n/c	n/c		n/c	n/c	n/c	n/c	n/c
Bonutti et.al.1994	n/c	n/c	n/c		n/c	n/c	n/c	n/c	n/c
Glasgow et.al.2003	n/c	n/c	n/c		n/c	n/c	n/c	n/c	n/c
Huang et.al.1978	n/c	n/c	n/c		n/c	n/c	n/c	n/c	n/c
Johnson & Silverberg 1995	n/c	n/c	n/c		n/c	n/c	n/c	n/c	n/c
Larson et.al.1971	n/c	n/c	n/c		**pos**	n/c	n/c	n/c	n/c
Richard R.1986	n/c	n/c	n/c		n/c	n/c	n/c	n/c	n/c
Richard et.al.2000	n/c	n/c	n/c		n/c	n/c	n/c	n/c	n/c
Richard et.al.1995	n/c	n/c	n/c		n/c	n/c	n/c	n/c	n/c
Ridgway et.al.1991	n/c	n/c	n/c		**pos**	n/c	n/c	n/c	n/c

Key: Neg = health indicator(s) considered to have negative effect on outcome; **Pos** = health indicator(s) considered to have positive effect on outcome; **N/C** = not considered

Table H14
Evidence Table

McMaster Quality Criteria	Bennett et al. 1989	Bonutti et al. 1994	Glasgow et al. 2003	Huang et al. 1978	Johnson & Silverberg 1995	Larson et al. 1971	Richard 1986	Richard et al. 2000	Richard et al. 1995	Ridgway et al. 1991
Study Purpose										
Stated clearly?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Relevant lit. review	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No
Design										
Type	BA/Q	BAC/D	SCT/Q	CC/E	CS/D	CS/D	CS/D	Co/E	SCD/Q	CS/D
Appropriate	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample										
Detailed	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Justified	No	No	Yes	Yes	N/A	N/A	N/A	No	N/A	N/A
Outcomes										
Reliable’	No	Yes	Yes	No	Yes	No	No	No	No	No
Valid	No	Yes	Yes	No	Yes	No	No	No	No	No
Intervention										
Detailed	No	No	Yes	No	Yes	No	Yes	No	Yes	Yes
Contamination avoided	N/A	N/A	Yes	N/A	N/A	N/A	N/A	No	N/A	N/A
Co-interventions avoided	No	No	No	No	No	No	No	No	No	No
Results										
Stat significance reported	No	No	Yes	No	No	No	No	Yes	No	No
Analysis appropriate (data level)	Yes-(d)	No-(d)	Yes-(i)	No-(d)	Yes-(r)	Yes-(r)	Yes- (r)	No-(i)	No-(d)	Yes-(r)
Clinical importance reported	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Drop-outs reported	No	No	Yes	Yes	No	No	No	Yes	Yes	No
Conclusions										
Appropriate	No	No	Yes	No	Yes	No	No	No	No	No
Quality rank	IC	IS	C	IS	C	IC	IC	IS	IS	IC

Key: Design types: BA=Before-and-after; BAC=Before-and-after case series; SCT=Sequential Clinical Trial; CC=Case-control; CS=Case study; Co=Cohort; SCD=Single case design
D=Descriptive; E=Exploratory, Q=Quasi-experimental; **Data Levels**: d=descriptive, i.=inferential , r=raw; **Ranks**: IC-Inconclusive, IS=Insufficient, C=Conclusive.

Table H15
Risk of Bias

Risk of bias		Bennett et.al. 1989	Bonutti et.al. 1994	Glasgow et.al. 2003	Huang et.al. 1978	Johnson & Silverberg 1995	Larson et.al. 1971	Richard 1986	Richard et.al. 2000	Richard et.al, 1995	Ridgway et.al. 1991
Design Methods/ Intervention bias	Co-intervention	x	x	x	x	x	x	x	x	x	x
	Maturation	N/A	x	N/A	x	N/A	x	x	x	x	N/A
	Inconsistent/ multiple therapists	x	N/A	x	x		x	x	x	x	x
Sample/ Selection bias	Volunteer/ referral bias	x	x		N/A	x	x	x	N/A	x	x
	Attention bias	x	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Disadvantaged vs. advantaged	N/A	N/A	x	x	N/A	N/A	N/A	x	N/A	N/A
	Population characteristics match	N/A	N/A		x	N/A	N/A	N/A	x	N/A	N/A
Data Collection/ Measurement bias	Consistent therapist		x		x		x	x	x	x	x
	Independent evaluation rater/interviewer bias	x	x	x		x	x	x		x	x
	Recall/memory bias	N/A	N/A	x	x	N/A	N/A	N/A	N/A	N/A	N/A

Note: Definitions: Co-intervention: More than one form of treatment at the same time can influence results in either direction (Law & McDermid, 2008)
Maturation: Changes that occur naturally over time that may affect the results of the study (Brink et al., 2006).
Inconsistent/Multiple Therapists: Different therapists may apply the intervention differently is such a way that the results are influenced (Law & McDermid, 2008)
Volunteer/referral bias: There is often a difference between people who are referred and those are not referred that can influence results (Law & McDermid, 2008).
Attention bias: Study subjects are normally aware of the purpose of the study and may perform better because of the attention they receive (Law & McDermid, 2008)
Disadvantaged vs advantaged: The groups may differ in ways that influence results such as disadvantage of severity of condition.(Law & McDermid, 2008)
Population characteristics match: Subjects in each group should be similar before the intervention to prevent difficulty attributing causality to the internvention (Brink et al., 2006)
Independent evaluation rater/Interviewer bias: Evaluator is blinded to which group the subject belongs to (Brink et al. 2006)
Recall/memory bias: Reality of event is different than recalled due to time since event – may be recalled more favourably. This is especially at risk with self report tools (Law & McDermid, 2008)
Key: x=possible risk, n/a = not applicable due to design

Table H16
Study Relevance Factors

StudyRelevance Factors considered in study		Bennett et.al. 1989	Bonutti et.al. 1994	Glasgow et.al. 2003	Huang et.al. 1978	Johnson& Silverberg 1995	Larson et.al. 1971	Richard R. 1986	Richard et.al. 2000	Richard et.al, 1995	Ridgway et.al. 1991
Person - Performance components	Physical functions & structures	√*	√*	√*	√*	√*	√*	√*	√*	√*	√*
	Cognition										
	Affect										
Environment	Social/financial considerations	√				√	√	√			
	Cultural consideration										
	Physical considerations		√	√						√	
	Institutional considerations										
Occupational purposes [+]	Self care activities/tasks	√						√		√	
	Leisure activities/tasks										
	Productivity activities/tasks		√								
Engagement	Active/passive participation	√	√	√	√	√	√	√			√
	Choice										
	Satisfaction		√*								
	Participation sporadic/ consultation	√	√	√	√	√	√			√	√
Applicable to clinical practice		√	√	√	√	√	√	√	√	√	√
Useful for OT research directions		√	√	√	√	√	√	√	√	√	√

Note: Relevance factors determined according to CMOP-E model framework.
[+]"*Occupations are composed of activities, which are composed of tasks, which are, in turn, composed of actions composed of voluntary movement and mental processes*". *Townsend, E. A., & Polatajko, H. J. (2007, p.34). Enabling occupation II: Advancing an occupational therapy vision for health, well being & justice through occupation. Ottawa, Ontario: CAOT Publications ACE.*
Key*:* √= relevance factor discussed √*= relevance factor considered an outcome in study

Appendix I

Resources

Table I17. Outcome Measurement Tools

Brief COPE
Access information:
(http://www.psy.miami.edu/faculty/ccarver/CCscales.html)

Technique: Casting Guidelines, Tips and Techniques
Access information:
(Casting Guidelines, Tips and Techniques: Proceedings of the 1997 American Burn Association PT/OT Casting Workshop. Staley,M.; Serghiou, M. Published in Journal of Burn Care and Rehabilitation 1998;19:254-260.)

Table I 17
Outcome Measurement Tools

Table of tools recommended by Falder et al. (2007)

Outcome	Name of tool	Comments
Joint mobility	Goniometry	Intra-rater reliability higher than inter-rater Method of choice for measuring ROM
Upper limb function	The Disability of the Arm Shoulder and Hand (DASH) Symptom Scale or QuickDASH	Self-report, QuickDASH is an abbreviated version Reliability & validity established in burns
Pain	The Brief Pain Inventory (BPI)	Measures pain intensity- solid psychometric properties, not tested in burns
	The Burn Specific Pain Anxiety Scale	Assesses burn related anxiety. Reliable & valid for burn population
Depression	Centre for Epidemiological Studies – Depressed Mood Scale (CES-D)	Absence of items of somatic nature(sleep, appetite, libido) Good psychometric properties – not commonly used in burns
Occupational function	The modified Barthel index (MBI)	10 scored activities. Good correlations with other tests, widely used and simple
Community Participation	The Community Integration Questionnaire	15 items self report Adequate reliability and internal consistency, not validated in burns
Perceived QOL	SF-36	Allow comparison of QOL in burns to other population norms
	Burn Specific Health Scale (BSHS)	Reliable and valid

Note: For an extensive list of recommendations and information on core outcomes for burn survivors and recommended tools refer to the entire article: Falder, S., Browne, A., Edgar, D., Staples, E., Fong, J., Rea, S., & Wood, F. (2009). Core outcomes for adult burn survivors: a clinical overview. *Burns (03054179), 35*(5), 618-641.