BURNS XXX (2016) XXX–XXX

Available online at www.sciencedirect.com
ScienceDirect
journal homepage: www.elsevier.com/locate/burns

Review

The effects of conservative treatments on burn scars: A systematic review

Mieke Anthonissen [a,b,*], *Daniel Daly* [c], *Thaïs Janssens* [a], *Eric Van den Kerckhove* [a,b,d]

[a] *KU Leuven, Department of Rehabilitation Sciences, Tervuursevest 101, 3001 Leuven, Belgium*
[b] *UZ Leuven, Department of Physical Medicine and Rehabilitation & Burns Center, Herestraat 49, 3000 Leuven, Belgium*
[c] *KU Leuven, Department of Kinesiology, Tervuursevest 101, 3001 Leuven, Belgium*
[d] *AZ Maastricht, Department of Plastic Surgery, P. Debyelaan 25, 6229 HX Maastricht, The Netherlands*

ARTICLE INFO

Article history:
Accepted 7 December 2015

Keywords:
Burn scar
Conservative treatment
Systematic review

ABSTRACT

A variety of conservative treatments for burn scars are available, but there is no clear consensus on the evidence. The purpose of this study was to summarize the available literature on the effects of conservative treatments of burn scars in adults. RCTs and CCTs were sought in three databases, reference lists of retrieved articles and relevant reviews. The Scottish Intercollegiate Guidelines Network scoring system was used to assess the quality of the selected studies. Information on the study characteristics, results and interventions was extracted. Twenty-two articles were included into the review and categorized in six topics: 5 on massage therapy, 4 on pressure therapy, 6 on silicone gel application, 3 on combined therapy of pressure and silicone, 3 on hydration and 1 on ultrasound. Pressure and silicone therapy are evidence-based conservative treatments of hypertrophic scar formation after a burn producing clinically relevant improvement of scar thickness, redness and pliability. Massage therapy could have a positive result on scar pliability, pain and pruritus, but with less supporting evidence. The use of moisturizers and lotions could have an effect on itching, but the findings are contradictory. Of all other non-invasive treatments such as splinting, casting, physical activity, exercise and mobilizations no RCTs or CCTs were found.

* *Corresponding author at*: Department of Rehabilitation Sciences, O&N IV Herestraat 49, Room: 04.04, KU Leuven Post Box: 1510, 3000 Leuven, Belgium. Tel.: +32 16 37 65 26; fax: +32 16 32 91 97.
E-mail addresses: mieke.anthonissen@faber.kuleuven.be (M. Anthonissen), daniel.daly@faber.kuleuven.be (D. Daly), thaisjanssens@hotmail.com (T. Janssens), eric.vandenkerckhove@faber.kuleuven.be (E. Van den Kerckhove).
http://dx.doi.org/10.1016/j.burns.2015.12.006
0305-4179/

Contents

1. Introduction

In the past severe burns were associated with considerable mortality rates [1]. Since the development of specialized burn centers and associated advances in treatment, more burn victims survive [1–3]. Due to long hospitalization and absence of daily physical activity and exercise, patients suffer from decreased muscle strength, reduced joint mobility and limited fitness level. Moreover, the formation of hypertrophic scars, even after minor burns, is a common complication and usually develops 6–8 weeks after re-epithelialization. These scars have a red to deep purple color and become more elevated, firm, hypersensitive, itchy, warm to touch, tend to contract and affect range of motion [4]. Subsequently, physiotherapy takes a crucial role in the acute treatment and rehabilitation process of burn patients and includes a variety of treatment methods such as exercise therapy, cardiopulmonary training, joint mobilization, positioning, splinting and topical scar management. However there is no consensus on the actual effect of the various treatment modalities and the evidence is not clear or even lacking. Therefore the purpose of this study was to summarize the available literature on the effects of conservative treatments of burn scars in adults.

2. Methods

2.1. Search strategy

Studies were sought in three databases PubMed, Embase and Web of Science. Full text articles on conservative treatments, such as pressure therapy, silicone gels, massage therapy, use of moisturizers, rehabilitation, physical activity, exercising, splinting, stretching and mobilization on burn scars in a population of adults were included. Inclusion criteria for the review involved a patient population of adults with burn scars and a conservative treatment intervention. The latest search data was January 12, 2015 (Table 1).

We also searched in PubMed on the terms ‘burn’ and ‘scar’ and ‘laser’, but this search led to a wide variety of different laser applications. Therefore, we did not to include laser therapy as treatment intervention in this review.

The reference lists of retrieved articles and relevant reviews were also examined for additional studies. The search was completed by two persons.

2.2. Inclusion and exclusion criteria after PICO

Two reviewers checked the titles of the studies found according to the search strategy described. Each relevant

Please cite this article in press as: Anthonissen M, et al. The effects of conservative treatments on burn scars: A systematic review. Burns (2016), http://dx.doi.org/10.1016/j.burns.2015.12.006

Table 1 – Search strategy.

Search details		
Burns	Scar	Pressure therapy
		Pressure garment
		Compression
		Silicone gel
		Gel sheets
		Gel sheeting
		Inserts
		Massage
		Topical treatment
		Hydration
		Lotion
		Cream
		Ointment
		Moisturizer
		Rehabilitation
		Stretching
		Splinting
		Casting
		Physical activity
		Exercise
		Mobilization
Limits		
Language		English, French, Dutch
Species		Humans
Age		All adults
Design		CCT, RCT

publication was categorized using a PICO model (Patient or Population, Intervention, Comparison, Outcome). Objective and subjective scar related parameters such as redness, pigmentation, pliability, thickness, texture, pain and pruritus and physical parameters such as joint motion and physical capacity were considered as relevant outcome measures.

2.3. Methodological quality assessment

The Scottish Intercollegiate Guidelines Network (SIGN) scoring system was used to assess the quality of the selected studies [25]. The methodology checklist for RCTs and CCTs as described by the SIGN was completed.

The internal validity of each article was scored in 10 questions on an appropriate and clearly focused question (1.1), randomization (1.2), concealment method (1.3), blinding (1.4), groups similarity at baseline (1.5), treatment under investigation (1.6), outcomes measured in standard, valid and reliable way (1.7), drop-out rate (1.8), intention to treat analysis (1.9) and comparable results for all sites (1.10). An overall assessment of the study provides an answer on how well the study was done to minimize bias, based on the 10 responses. Studies could be seen as high quality (++) if the majority of the criteria met with little or no risk of bias. Results were unlikely change by further research. Studies in which most criteria met with an associated risk of bias have an acceptable (+) quality. Conclusions may change in the light of further studies. Studies can be seen as low quality (0) if either most criteria are not met, or have significant flaws relating to key aspects of study design. Conclusions of these studies could likely change in the light of further studies.

2.4. Data processing

Information on the study characteristics, results and interventions was extracted from the included studies via a fixed protocol sheet.

3. Results

3.1. Trial flow

Via PubMed 1224 articles were identified. Of these publications, 1181 were excluded with limits activated for language, species, age and study design. Forty-three articles were screened on title and abstract, whereof 23 were excluded for not meeting the inclusion criteria (patient population, treatment intervention and outcome measures). Twenty articles were retrieved. Additional search using Embase led to one extra article. A search on Web of Science did not deliver additional studies. Another article was found while examining relevant reviews, references and bibliographic lists of the retrieved articles. Twenty-two studies were thus included into the review. The flow chart of the systematic literature search is presented in Table 2. Table 3 lists all included studies sorted by topic. Studies appeared; first, from high quality (++) to low quality (0) with the most recently published first.

3.2. Methodological quality

According to the SIGN criteria, 5 articles were judged to be at low risk of bias [5–9]. These studies can be seen as high quality studies. Eleven studies had acceptable quality [4,10–19] and 6 were of low quality [20–25] (Table 4). In 10 studies there was no drop out [4,12,15,17–19,21,22,24,25], the remaining 12 articles had a drop out ranging from 6.7% to 30.4% [5–11,13,14,16,20,23]. Eighteen studies were randomized trials [4–11,13–19,22–24], but 14 studies used a poor randomization method (no computer generated allocation) [4,8–11,13,15–19,22–24].

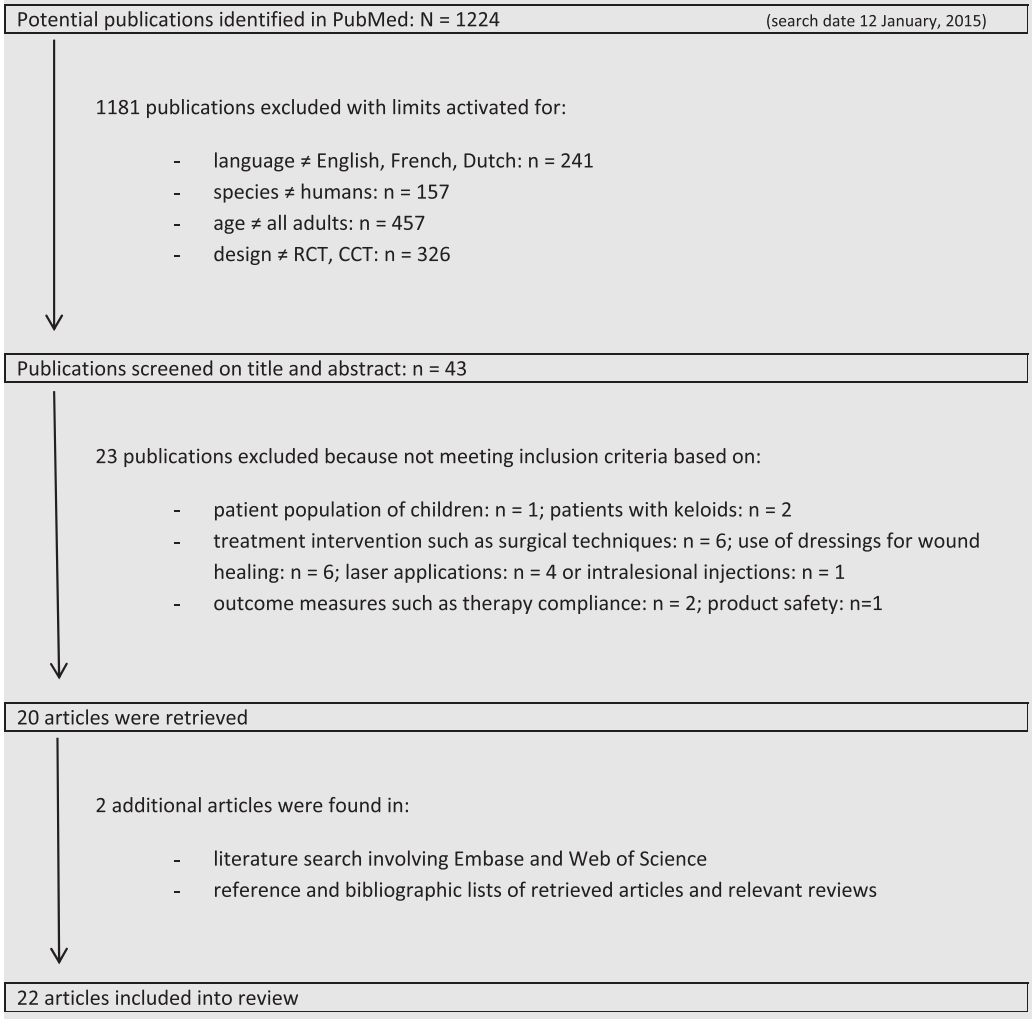
3.3. Study characteristics (Appendix A)

Five studies compared *massage therapy* on burn scars with standard care [5,12,17,19] or no treatment [21]. Of the 4 studies related to *pressure therapy* 1 study compared pressure therapy with no pressure garments [23] and 3 compared with lower pressure groups [4,8,10]. Six articles dealt with the effects of *silicone treatment* on hypertrophic burn scars, 4 made the comparison between silicone therapy and an untreated scar control group [16,25] or a placebo group [9,13], one article compared two types of silicones with a control site [18] and another compared only 2 types of silicone [22]. Three studies were found for the *combination therapy of pressure and silicone*. One of these studies evaluated the difference between the combination therapy and only pressure therapy [14]. One compared combined therapy, pressure therapy and silicone therapy with a control group [11]. Another compared silicone spray and pressure, silicone gel sheet and pressure or only pressure on post-burn scars [7]. Three articles studied the effect of *hydration* on burn scars. In two studies a lotion/moisturizer was compared with

Please cite this article in press as: Anthonissen M, et al. The effects of conservative treatments on burn scars: A systematic review. Burns (2016), http://dx.doi.org/10.1016/j.burns.2015.12.006

Table 2 – Flow chart of systematic literature search.

Table 2. Flow chart of systematic literature search



a control ointment/moisturizer [6,20], in another silicone gel, silicone gel sheet and a topical extract were compared [15], The remaining study made a comparison between *ultrasound* and passive stretching and passive stretching alone [24].

3.4. *Participants (Appendix A)*

Within the 5 studies of *massage therapy*, 251 patients (ranging from 10 to 160 patients) participated with a lost-to-follow-up

Table 3 – Selected RCTs and CCTs.

Massage therapy	Pressure therapy	Silicone application therapy	Combined therapy of pressure and silicone	Hydration	Ultrasound application
Silverberg et al. [19] 1996	Chang et al. [23] 1995	Ahn et al. [25] 1991	Harte et al. [14] 2009	Ogawa et al. [20] 2008	Ward et al. [24] 1994
Field et al. [17] 2000	Van den Kerckhove et al. [4] 2005	Carney et al. [18] 1994	Li-Tsang et al. [11] 2010	Karagoz et al. [15] 2009	
Roh et al. [21] 2007	Engrav et al. [10] 2010	Lee et al. [22] 1996	Steinstraesser et al. [7] 2011	Nedelec et al. [6] 2012	
Roh et al. [12] 2010	Candy et al. [8] 2010	Li-Tsang et al. [16] 2006			
Cho et al. [5] 2014		Momeni et al. [9] 2009			
		Van der Wal et al. [13] 2010			

Table 4 – SIGN scoring system: methodology checklist for CCT and RCT.

	1.1 Clear question	1.2 Randomization	1.3 Concealment method	1.4 Blinding	1.5 Groups similarity at baseline	1.6 Treatment under investigation	1.7 Standard, valid and reliable way	1.8 Drop-out rate	1.9 Intention to treat analysis	1.10 Comparable results for all sites	2.1 Overall bias rating
Cho et al. [5]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8.7%	No	Not applicable	++
Nedelec et al. [6]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	21.7%	Yes	Not applicable	++
Steinstraesser et al. [7]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11.6%	No	Not applicable	++
Candy et al. [8]	Yes	Yes[a]	No	Yes	Yes	Yes	Yes	8.6%	No	Not applicable	++
Momeni et al. [9]	Yes	Yes[a]	Yes	Yes	Yes	Yes	Yes	10.5%	No	Can't say	++
Engrav et al. [10]	Yes	Yes[a]	No	No	Yes	Yes	Yes	19.4%	No	Not applicable	+
Li-Tsang et al. [11]	Yes	Yes[a]	No	Yes	No	Yes	Yes	19.2%	No	Not applicable	+
Roh et al. [12]	Yes	No	No	Yes	Yes	Yes	Yes	0%	Not applicable	Not applicable	+
Van der Wal et al. [13]	Yes	Yes[a]	No	Yes	Yes	Yes	Yes	30.4%	No	Can't say	+
Harte et al. [14]	Yes	Yes	Yes	Yes	No	Yes	Yes	26.6%	No	Not applicable	+
Karagoz et al. [15]	Yes	Yes[a]	No	No	Can't say	Yes	Yes	0%	Not applicable	Not applicable	+
Li-Tsang et al. [16]	Yes	Yes[a]	No	Yes	No	Yes	Yes	6.7%	No	Can't say	+
Van den Kerckhove et al. [4]	Yes	Yes[a]	No	No	No	Yes	Yes	0%	Not applicable	No	+
Field et al. [17]	Yes	Yes[a]	No	No	Yes	Yes	Yes	0%	Not applicable	Not applicable	+
Silverberg et al. [19]	Yes	Yes[a]	No	Yes	No	Yes	Yes	0%	Not applicable	Not applicable	+
Carney et al. [18]	Yes	Yes[a]	No	No	Yes	Yes	Yes	0%	Not applicable	No	+
Ogawa et al. [20]	Yes	No	No	No	Can't say	Can't say	No	6.7%	No	Not applicable	0
Roh et al. [21]	Yes	No	No	No	Yes	Can't say	Yes	0%	Not applicable	No	0
Lee et al. [22]	Yes	Yes[a]	No	No	No	Yes	No	0%	Not applicable	Can't say	0
Chang et al. [23]	Yes	Yes[a]	No	Yes	Yes	No	No	13.9%	No	Not applicable	0
Ward et al. [24]	Yes	Yes[a]	No	Yes	Can't say	Yes	No	0%	Not applicable	Can't say	0
Ahn et al. [25]	Yes	No	No	No	Yes	Yes	No	0%	Not applicable	Can't say	0

[a] Randomization but poor method.
++; +; 0 good; acceptable; low quality.

Please cite this article in press as: Anthonissen M, et al. The effects of conservative treatments on burn scars: A systematic review. Burns (2016), http://dx.doi.org/10.1016/j.burns.2015.12.006

rate of 5.6%. The mean age ranged from 33 to 51 years old. Average time after burn varied from 3.5 to 6.4 months [5,12,17,19,21]. Two studies included patients of White, Hispanic, Black or African American origin [17,19], although most patients were Korean burn survivors [5,12,21].

In the studies of the *pressure therapy* 253 patients (ranging from 17 to 122 patients) were included with a dropout rate of 7.3% and a lost-to-follow-up rate of 5.1%. The mean age of patients varied from 24 to 37 years old [4,8,10,23]. Average time after burn and ethnicity were not reported in 1 study [23], in the remaining studies, time after burn ranged from 0.5 to 5.5 months and studies included Caucasian, White, Non-White and Asiatic patients [4,8,10].

Two hundred and twelve patients participated in the studies of the effects of *silicone application*. These studies had a dropout rate of 1.4% and lost-to-follow-up rate of 5.2%. Mean age was from 22 to 45 years old [9,13,16,18,22,25]. Time after burn was not mentioned in two studies [16,18], in the other studies, average time after burn ranged from 2 to 24 months [9,13,22,25]. Ethnicity was not reported in three studies [9,13,18], in the other studies Black, White, Chinese, Indian, Malays and Eurasian patients were included [16,22,25].

Within the 3 studies of *pressure and silicone therapy*, 177 patients were included with a lost-to-follow-up rate of 4.5% and a high drop-out rate of 14.1%. Mean age varied from 22 to 43 years old [7,11,14]. Time after burn ranged from 3.3 to 14.9 months [11,14] and was unknown in one study [7]. In one study ethnicity was not mentioned [7], in the other studies participants were Caucasian [14] or Chinese [11].

The effect of the *use of moisturizer* was investigated in three studies. Seventy patients were included with a drop-out rate of 8.6% [6,15,20]. In two studies mean age ranged from 24 to 56 years old [15,20] and in another study patients were 18 years or older [6]. Months post-injury was not mentioned in one study [20], in two others time after burn varied from 0.77 to 4.5 months [6,15]. In two studies ethnicity was not reported [15,20], in the last Caucasian, Asian, East Indian, Latin and native American patients were included [6].

In the only study on the effects of *ultrasound* 9 patients with a mean age of 36 years old were included. There was no drop-out. No further information about time after burn and ethnicity was given [24].

3.5. Intervention (Appendix B)

In all studies *massage therapy* (Appendix B.1) was applied by a therapist using various techniques without lubricant [19] or lubricants such as cocoa butter [17], occlusive dressing [12,21] and moisturizing Emu oil [5]. The frequency and duration of massage sessions varied from a single 15 min treatment [19], 30 min, twice a week during 5 weeks (300 min) [17], 30 min, once a week during 12 weeks (360 min) [21] to 30 min, three times a week for 12 weeks (1080 min) [5,12]. In the studies of Roh et al. patients were also instructed to moisturize themselves daily during 10 min for 12 weeks (840 min) [12,21].

Pressure therapy (Appendix B.2) was applied until burn wound maturation [23], during 12 weeks [4], during 20 weeks [8] or during 52 weeks [10]. In one study no detailed information on daily wearing time was reported [23], in the other studies patients were instructed to wear the pressure garments for 23 h per day except for hygienic measures [4,8,10]. The applied pressure in the normal pressure groups varied from 17 mmHg to 25 mmHg [4,8,10]. The types of pressure garments were not reported in two studies [8,23], in the two remaining studies Tricolast and Anvarex [4] or Medical Z [10] were used.

In the studies on *silicone therapy* (Appendix B.3) different types of silicone were used such as silicone gel sheets [25], Cica-care silicone gel sheets [9,16,18], silastic gel sheets [18], Sil-K and Epiderm silicone sheets [22] and Dermatix topical silicone gel [13]. Patients were asked to wear silicone 12–24 h a day (except bathing time) during 16 weeks [9], during 24 weeks [16,18,22] or during 28 weeks [25]. In one study silicone topical gel was applied twice daily during 12–28 weeks [13].

In studies of *silicone and pressure therapy* (Appendix B.4) various pressure garments and silicone sheets/sprays were used. Jobskin pressure garments were used in two studies [7,14] and Mepiform silicone sheets were applied in one study [14]. No details about type of pressure garments or silicone were mentioned in the remaining studies [7,11]. This combined therapy was applied 23–24 h a day (except bathing time) for 24 weeks [11,14]. In another study combined therapy was continued until 48 weeks, although wearing time of pressure garments and applying time of silicone spray/sheet was not reported [7].

The effect of *moisturizers* (Appendix B.5) was investigated using three different types of moisturizers namely: Mugwort lotion [20], topical onion extract [15] and Protease containing moisturizer [6]. Treatment time and frequency varied from at least 3 times a day during 4 weeks [6], twice a day during 8 weeks [20] to twice a day for 24 weeks [15].

The effect of *ultrasound* (Appendix B.6) was examined using AMREX model machine during 10 min, three times a week for 2 weeks [24].

3.6. Outcome measurement

Typically, subjective rating scales were used to assess scar tissue such as the Vancouver scar scale (VSS) [7,8,11,15,16,19,21,23], modified VSS (mVSS) [6,9,14], subjective skin status (SSS) [21], patient and observer scar assessment scale (POSAS) [12,13] or other scales [10,18,22]. These scales incorporated parameters such as pigmentation, pliability, vascularity, height, etc. Itching was investigated using the 10-cm visual analog scale (VAS) [5,7,16,17], the Itch man scale [21] or other [6,20]. Pain was examined using VAS [5,7,16,17,24], Mc Gill questionnaire and present pain intensity [17].

A variety of instruments were used to objectively measure scar thickness, color and elasticity. To measure scar thickness, ultrasonography [5,10,12], Dermascan [4] and tissue ultrasound palpation system (TUPS) [8,11,16] were used. Mexameter [5,6], Minolta Chromameter [4,7,10], Spectrocolorimeter [8,11,16] and Dermaspectrometer [13] were used to investigate scar color (pigmentation and erythema). Elasticity (hardness/extensibility) was measured using Cutometer [5], Durometer [10] and elastometer [25], extensometer [18]. Only 1 study included blood perfusion using laser Doppler blood perfusion imager [12], transepidermal water loss (TEWL) and sebum using Tewameter and Sebumeter, respectively [5] and scar surface using PRIMOS microtopography [7]. In two studies

joint mobility was investigated using a goniometer [19] or other means (not reported) [24].

Three studies included additional outcomes like depression, anxiety or burn specific health [12,17,21]. Although these were important outcomes, in regard of the topic of this review, these were none of our interest and therefore not reported.

3.7. Study results

3.7.1. Massage therapy (Appendix C.1)

Of the 5 studies in this comparison one study was judged as good quality [5], 3 had acceptable quality [12,17,19] and 1 had low quality [21]. Silverberg and co-authors measured no significant differences in total ROM, pliability and vascularity between groups after a single treatment of 15 min massage therapy compared to a control group who received only standard therapy [19]. In the study of Field and coworkers an immediate significant reduction of itching and pain was observed after one treatment of 30 min massage therapy. These findings were again confirmed after 5 weeks of massage therapy compared to the standard medical care group [17]. A significant reduction of pruritus and improvement of VSS and SSS was shown after 12 weeks of massage therapy in the study of Roh in 2007 [21]. Although in 2010 Roh and coworkers found no significant differences in blood perfusion, thickness and POSAS in the massage group compared to the routine care group without massage [12]. On the other hand Cho and co-authors showed significant improvements in pain and itching in the massage group compared to the standard therapy group. Moreover a significant intergroup difference in thickness, melanin, erythema, TEWL, immediate distention and gross skin elasticity was seen in favor of the massage group [5].

3.7.2. Pressure therapy (Appendix C.2)

In this intervention one study had good quality [8], 2 had acceptable quality [4,10] and another had low quality [23]. A decrease in erythema over time was found in all pressure groups but there was no significant difference in decrease of erythema between a normal and a low compression group [4,10]. In the most recent study of Candy and coworkers however, there was a significantly higher effect on decrease of redness in the normal compression group (pressure of 20–25 mmHg) [8].

A significant reduction of thickness was shown in all pressure groups, although scar reduction is higher in the normal compression group compared to the lower compression group [4,8,10]. Engrav and co-authors reported differences in thickness of $\geq$1 mm in 5 of the 28 patients which would be clinically detectable [10].

Hardness was found to be statistically significantly lower in a normal compression group compared to a low compression group [10]. No statistically significant decrease in pliability was shown in pressure groups [8] and there was no significant difference in time to wound maturation between normal and low compression groups [23].

3.7.3. Silicone gel application (Appendix C.3)

Of the 5 studies in this comparison only one study was judged as good quality [9], 3 had acceptable quality [13,16,18] and 2 had low quality [22,25]. In almost all studies elasticity was assessed and significant improvements in favor of the silicone gel group were found [9,16,18,25] with one exception [13]. In some cases elasticity was measured objectively [18,25] while in others it was assessed using subjective scales [9,13,16]. The treatment effect plateaued after 2 months in only one study [25], in others significant intergroup differences remained at 4 or 6 months treatment compared to the control group [9,16,18].

According to some authors, redness, vascularity or erythema were found to improve after silicone gel treatment [9,13,18,22], although only significantly compared to the control group based on subjective rating scales in 2 studies [9,18]. These findings were not confirmed by an objective instrument [13].

In three studies, thickness was an outcome measure and diminished over time in all three studies [13,16,22] but only significantly in one study compared to a control group and based on an objective measurement method [16]. Itching was also regularly assessed as outcome measure [9,13,16]. In 2 of 3 studies it was found to be significantly improved in the treatment arm [9,13].

3.7.4. Combined therapy of pressure and silicone (Appendix C.4)

In this intervention one study had good quality [7], two other studies had acceptable quality [11,14]. In all three studies a subjective rating scale was used (VSS, mVSS or VAS) and showed improvements in different (sub)items over time [7,11,14]. However only pliability was significantly better in the combined therapy group compared to the control group after 2 and 4 months [11]. Pain was significantly improved in the silicone gel sheet group and combined therapy group at follow-up compared to the control group [11].

Thickness was only assessed objectively in one study and turned out to be significantly improved in the combined therapy group at 2, 4 and 6 months treatment compared to the control group [11]. Scar surface improved in the combined therapy (silicone spray and compression) group compared to the control group [7].

3.7.5. Hydration (Appendix C.5)

In this intervention one study had good quality [6], other studies had acceptable quality [15] and the last had low quality [20]. After 2 months of mugwort lotion application itching significantly improved compared to control groups [20]. In addition the use of Provase containing moisturizer reduced significantly the duration of itch episodes, the duration of itching per week and the mean TBSA itch region. The itch characteristic ''itch seen as bothersome'' was significantly decreased after 4 weeks in the Provase group compared to the control group [6].

On the other hand Karagoz proved the superior effect of silicone therapy to the use of topical onion extract. Silicone groups showed significantly better results in VSS compared to topical onion extract group [15].

3.7.6. Ultrasound (Appendix C.6)

This study was of low quality following the SIGN guidelines [24]. Ward and co-authors found no results to show the added value of ultrasound in the joint mobility of burn patients [24].

Please cite this article in press as: Anthonissen M, et al. The effects of conservative treatments on burn scars: A systematic review. Burns (2016), http://dx.doi.org/10.1016/j.burns.2015.12.006

4. Discussion

4.1. Massage therapy

A reduction of pain and/or itching was shown in 3 of 5 studies [5,17,21]. Improvement of patient's perspectives on scar related characteristics was only found in the study of Roh and co-authors of 2007, but these findings were not confirmed by Roh and coworkers in 2010, even though in the latter study the frequency of massage treatment was three times higher than the study of 2007, nonetheless the sample size was smaller, only two thirds of the sample size of Roh et al. in 2007 [12,21]. All these findings were based on subjective rating scales and mostly based on trials with small sample sizes [12,17,21]. The number of patients in the massage group varied from 10 to 18 patients [12,17,21], with the exception of the most recent study of Cho and coworkers with 76 patients in the intervention group [5].

Cho and co-authors in their recent high quality study did find promising results on scar tissue using objective scar assessment tools. Improvements of thickness, melanin, erythema, TEWL and elasticity on burn scars were seen in the massage group [5]. However these results were not found in the study of Roh and co-authors, probably because of the small sample size and different massage technique [12]. Since assorted massage techniques were applied in the studies, with various duration and frequency of treatment, with or without use of moisturizer, and using diverse population [5,12,17,19,21], it was not possible to compare these five studies. Therefore conclusions should be made carefully. Potential positive results of massage therapy on burn scars could be the improvement of pliability due to the mechanical disruption of fibrotic scar tissue [26]. The reduction of pain and pruritus could be supported by the gate theory of Melzack and Wall [27].

Future research should focus on, larger sample sizes, the use of objective tools and well-designed clinical trials with clear guidelines concerning applied massage technique, appropriate timing after wound closure, frequency and duration of treatment [26].

4.2. Pressure therapy

The meta-analysis by Anzarut and coworkers showed a trend toward a decrease in scar thickness in the pressure therapy group compared to the control group [28]. For vascularity, pliability and color there were no significant differences between groups in the meta-analysis [28]. In this review 3 studies, in which objective assessment tools for thickness were used, showed a significant reduction in thickness after application of pressure [4,8,10]. In addition, the higher the amount of pressure, the better the effect on decrease of thickness [4,8,10]. Nevertheless, there was no clear consensus about the minimum effective amount of pressure. Some authors suggested a pressure of at least 15 mmHg [10]. Others recommended pressure of 24 mmHg to overcome capillary pressure [4]. In the normal compression group a pressure of approximately 20 mmHg or higher was achieved, the pressure of the low compression group was only 15 mmHg or even less [4,8,10]. Higher pressure was more effective in flattening of burn scars and resulted in thinner scars. Pressure greater than 40 mmHg could result in complications such as paresthesia [10]. All authors agreed that patients need to wear pressure garment during 14–23 h/day.

A decrease of erythema over time was confirmed in different groups using pressure garments [4,8]. The influence of the amount of pressure on erythema was only seen in the high quality study (following SIGN score) of Candy and co-workers [8] and not in the study of Van den Kerckhove et al. [4]. However both authors used an objective measurement tool, respectively Spectrocolorimeter and Minolta Chromameter, and the amount of pressure in the normal compression group and low compression group were comparable, respectively approximately 20 mmHg and around 12 mmHg. Other reasons could explain this discrepancy: intervention time was 20 weeks versus only 12 weeks; time after burn was almost 5 months versus only 0.5 months and the patient population was Asiatic versus Caucasian in respectively Candy et al. and Van den Kerckhove et al. [4,8]. Kim et al. reported important differences between Asian and Caucasian skin. Asian skin is characterized by increased proliferation of fibroblast and more vigorous collagen formation which results in a prolonged erythema compared to Caucasian skin. As a consequence, in Asians most scars take longer to mature [29]. Therefore it was not surprising that the results of both studies were not in agreement.

Significant improvements in hardness were only found in the normal compression group and not in the low compression group [10]. Following the manufacturer a difference in hardness of 10 durometer units was evident to palpation and a difference of 5 units was seen as the absolute minimum to be clinically detectable. In 10 out of 19 patients a hardness difference exceeded 5 durometer units and in only 3 of those the difference exceeded 10 durometer units [10]. Pliability was improving in both groups, but not significantly [8]. So far, these outcomes were not assessed in another trial.

In the study of Chang and co-authors and in the study of Engrav and co-authors a drop-out rate was registered of respectively 13.9% and 19.4% [10,23]. These appear to be relatively high drop-out rates, nevertheless following the SIGN guidelines a 20% drop-out rate was regarded as acceptable.

Since pressure is more effective if high enough, above 20 mmHg, it is important to regularly check and evaluate pressure garments, e.g. using the Kikuhime pressure sensor [30]. Moreover pressure loss of pressure garments needs to be taken into account. In some anatomical regions, e.g. the axilla or the chest, it is not possible to obtain a pressure of at least 20 mmHg. In these cases pressure pads can be useful and usually worn in combination of classical pressure garments [31].

The overview in this review proved positive effects in decrease of scar thickness [4,8,10], supported by the guidelines of Monstrey and co-authors [32]. So far, the working mechanism was based on the effect of pressure on the realignment of collagen fibers and the reduction of development of whorled typed collagen nodules, which might induce thinning of scars [8,33,34]. Moreover this summary also found diminishing values of scar redness [8]. Following Candy and co-authors, this might be an indicator for the reduction of vascular flow to

Please cite this article in press as: Anthonissen M, et al. The effects of conservative treatments on burn scars: A systematic review. Burns (2016), http://dx.doi.org/10.1016/j.burns.2015.12.006

scar tissue, which lead to a decrease of nutrient and oxygen supply for cellular activities and might accelerate apoptosis of fibroblasts [8,33,35–38].

4.3. *Silicone gel application*

Clearly, in these studies different types of silicone were used, such as silicone sheets (not further specified) [25], cica-care silicone gel sheets [16,18], silastic gel sheets [18], Sil-K silicone and Epiderm silicone sheets [22] or Dermatix topical silicone gel [13] in diverse patient populations, such as Black and White [25], Chinese, Indians, Malays and Eurasian [22], only Chinese [16] or even not reported in detail in some European studies [9,13,18]. The silicone gel sheets were typically worn 12–24 h a day, excluding bathing time. The topical silicone gel was applied twice a day. Therapy compliance and daily hygiene were not registered. The duration of this intervention was sufficient in all studies, varying between 12 and 28 weeks.

In almost all studies, elasticity was assessed and showed significant improvements in 4 studies [9,16,18,25] based on assessment with both subjective and objective tools. Positive effects on redness, however subjectively assessed, were also shown in 3 studies [9,18,22]. Additionally the use of silicone gel application produced some promising results on thickness [16,22] and itching [9,13], although mostly based on subjective outcome measures.

The mechanism of action of silicone was postulated as improving skin hydration from occlusion of the silicone and reducing fibroblast's activity and collagen formation [16,39]. This working mechanism supports the effect of silicone on elasticity and redness.

4.4. *Combined therapy*

Since silicone and pressure therapy had complementary modes of action. It appeared to be evident that the combined therapy of silicone and pressure would give mixed results. However all 3 studies in this review presented different results. In one article no significant results between groups were found. This was probably because no control group without therapy was included or there was only a small sample size [14]. In only one study thickness was objectively assessed and a decrease of scar thickness was found after 2, 4 and 6 months [11]. In the same study, likewise an increase of pliability in favor of the combined therapy compared to the control after 2 and 4 months treatment was shown [11]. The major differences between the latter study and the two others were the higher sample size, the Chinese population and the long time after burn at start of the treatment in the study of Li-Tsang and co-authors [11].

The use of different types of silicone gel sheets or sprays, the variation in ethnicity [29] and the difference in time after burn at treatment onset [29] could explain these inconclusive results [7,11,14].

In addition to the anatomical regions discussed in the section about pressure therapy, silicone inserts, which are custom made based on an imprint of the scarred limb or body part, can also be used in combination with pressure garments, masks or splints. The benefit of this technique is the individually tailored manufacture and fitting and the ideal solution for concavity problems. On the other hand it can limit the mobility when used over a joint and macerate the skin due to excessive sweating [31]. However in none of these included studies custom made silicone elastomers were used.

4.5. *Hydration*

A variety of different moisturizers and lotions were available. To our knowledge only three randomized controlled or controlled clinical trials examined the effect of a specific topical agent on burn scars [6,15,20]. None of these investigated the effect of the same product and only 2 of those showed improvements in favor of the topical lotion, especially on the level of itching [6,20]. Moreover, these studies had relatively small sample sizes (ranging from 15 to 32 patients), diverse treatment interventions (ranging from 8 to 24 weeks) and results were based on subjective rating scales.

All authors supported the need for scar tissue hydration, since scars showed increased transepidermal water loss rates compared to healthy skin [40–42]. But little is known about the ideal composition of moisturizers for burn scar treatment [42]. Future research should focus on well-designed trials, preferably double blind and placebo-controlled with large sample sizes.

4.6. *Ultrasound*

Ward and co-workers did a randomized placebo controlled double blind study, with a low overall bias rating score. No significant intergroup results on range of motion and pain were found [24]. So far, no hypothesis concerning the mechanism behind this therapy intervention have been presented. Future research should focus on a larger sample size, a longer intervention and follow-up period, a well-designed study protocol and the development of a rational behind the treatment.

5. Conclusion

Pressure and silicone therapy are the most popular and evidence-based conservative treatments of hypertrophic scar formation after a burn [32]. Pressure or compression therapy improves scar thickness and probably decreases scar redness. Silicone therapy showed positive effects on scar pliability and redness. Massage therapy could have a positive effect on scar pliability, pain and pruritus, but with less supported evidence [32]. The use of moisturizers and lotions are popular well-known treatments of scar tissue and could have an effect on itching, although the ideal composition of moisturizer is unknown. Even if we eliminated results of the low quality studies [15,20–25], the conclusion would the same.

Of all other non-invasive treatments such as splinting, casting, physical activity, exercise and mobilizations no RCTs or CCTs were found. Nevertheless these therapies are frequently used in the treatment of burn scars.

Several shortcomings in this review must be identified. First, the amount of studies within each category was rather low. Even within a category, different techniques of e.g.

Please cite this article in press as: Anthonissen M, et al. The effects of conservative treatments on burn scars: A systematic review. Burns (2016), http://dx.doi.org/10.1016/j.burns.2015.12.006

massage therapy and various types of silicones or moisturizers were used. Together with the diverse ethnic patient population it could lead to inconclusive results. Next, as a consequence of the diversity of various levels such as patient population, treatment techniques or products, duration of intervention and assessment tools we were not able to do a meta-analysis. Finally, in this review we included all studies, which met the inclusion criteria, regardless of the quality score. Low quality studies could not be included in a meta-analysis.

6. Future recommendations

Future research needs to focus on comparative trials that compare different therapeutic modalities in well-designed protocols. Moreover in research settings we recommend the use of both subjective scar assessment scales and objective scar assessment tools to evaluate all scar characteristics. The effects of massage therapy, simple and non-expensive moisturizers, ultrasound, splinting and casting, and the effects of physical activity, exercise and mobilizations need particularly to be investigated in large multicenter trials with sufficient sample sizes.

Conflict of interest statement

No conflict of interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.burns.2015.12.006.

REFERENCES

[1] Brusselaers N, Monstrey S, Vogelaers D, Hoste E, Blot S. Severe burn injury in Europe: a systematic review of the incidence, etiology, morbidity, and mortality. Crit Care 2010;14:R188.
[2] Brusselaers N, Hoste EAJ, Monstrey S, Colpaert KE, De Waele JJ, Vandewoude KH, et al. Outcome and changes over time in survival following severe burns from 1985 to 2004. Intensive Care Med 2005;31:1648–53.
[3] Esselman PC, Thombs BD, Magyar-Russell G, Fauerbach JA. Burn rehabilitation: state of the science. Am J Phys Med Rehabil 2006;85:383–413.
[4] Van den Kerckhove E, Stappaerts K, Fieuws S, Laperre J, Massage P, Flour M, et al. The assessment of erythema and thickness on burn related scars during pressure garment therapy as a preventive measure for hypertrophic scarring. Burns 2005;31:696–702.
[5] Cho YS, Jeon JH, Hong A, Yang HT, Yim H, Cho YS, et al. The effect of burn rehabilitation massage therapy on hypertrophic scar after burn: a randomized controlled trial. Burns 2014;1–8.
[6] Nedelec B, Rachelska G, Parnell L, Lasalle L. Double-blind, randomized, pilot study assessing the resolution of postburn pruritus. J Burn Care Res 2012;33:398–406.
[7] Steinstraesser L, Flak E, Witte B, Ring A, Tilkorn D, Hauser J, et al. Pressure garment therapy alone and in combination with silicone for the prevention of hypertrophic scarring: randomized controlled trial with intraindividual comparison. Plast Reconstr Surg 2011;128:306–13.
[8] Candy LHY, Cecilia L-TWP, Ping ZY. Effect of different pressure magnitudes on hypertrophic scar in a Chinese population. Burns 2010;36:1234–41.
[9] Momeni M, Hafezi F, Rahbar H, Karimi H. Effects of silicone gel on burn scars. Burns 2009;35:70–4.
[10] Engrav LH, Heimbach DM, Rivara FP, Moore ML, Wang J, Carrougher GJ, et al. 12-Year within-wound study of the effectiveness of custom pressure garment therapy. Burns 2010;36:975–83.
[11] Li-Tsang CWP, Zheng YP, Lau JC. A randomized clinical trial to study the effect of silicone gel dressing and pressure therapy on posttraumatic hypertrophic scars. J Burn Care Res 2010;31:448–57.
[12] Roh Y, Seo C, Jang K. Effects of a skin rehabilitation nursing program on skin status, depression, and burn-specific health in burn survivors. Rehabil Nurs 2010;35:65–9.
[13] Van der Wal M, van Zuijlen P, van de Ven P, Middelkoop E. Topical silicone gel versus placebo in promoting the maturation of burn scars: a randomized controlled trial. Plast Reconstr Surg 2010;126:524–31.
[14] Harte D, Gordon J, Shaw M, Stinson M, Porter-Armstrong A. The use of pressure and silicone in hypertrophic scar management in burns patients: a pilot randomized controlled trial. J Burn Care Res 2009;30:632–42.
[15] Karagoz H, Yuksel F, Ulkur E, Evinc R. Comparison of efficacy of silicone gel, silicone gel sheeting, and topical onion extract including heparin and allantoin for the treatment of postburn hypertrophic scars. Burns 2009;35:1097–103.
[16] Li-Tsang CW, Lau JCM, Choi J, Chan CC, Jianan L. A prospective randomized clinical trial to investigate the effect of silicone gel sheeting (Cica-Care) on post-traumatic hypertrophic scar among the Chinese population. Burns 2006;32:678–83.
[17] Field T, Peck M, Hernandez-Reif M, Krugman S, Burman I, Ozment-Schenck L. Postburn itching, pain, and psychological symptoms are reduced with massage therapy. J Burn Care Rehabil 2000;21:189–93.
[18] Carney SA, Cason CG, Gowar JP, Stevenson JH, McNee J, Groves AR, et al. Cica-Care gel sheeting in the management of hypertrophic scarring. Burns 1994;20:163–7.
[19] Silverberg R, Johnson J, Moffat M. The effects of soft tissue mobilization on the immature burn scar: results of a pilot study. J Burn Care Rehabil 1996;17:252–9.
[20] Ogawa R, Hyakusoku H, Ogawa K, Nakao C. Effectiveness of mugwort lotion for the treatment of post-burn hypertrophic scars. J Plast Recontr Aesthet Surg 2008;61:210–2.
[21] Roh YS, Cho H, Oh JO, Yoon CJ. Effects of skin rehabilitation massage therapy on pruritus, skin status, and depression in burn survivors. J Korean Acad Nurs 2007;37:221–6.
[22] Lee S, Ngim C, Chan Y, Ho M. A comparison of Sil-K and Epiderm in scar management. Burns 1996;22:483–7.
[23] Chang P, Laubenthal KN, Lewis RW, Rosenquist MD, Lindley-Smith PKG. Prospective, randomized study of the efficacy of pressure garment therapy in patients with burns. J Burn Care Rehabil 1995;19:473–5.
[24] Ward R, Hayes-Lundy C, Reddy R, Brockway C, Mills PJRS. Evaluation of topical therapeutic ultrasound to improve response to physical therapy and less scar contracture after burn injury. J Burn Care Rehabil 1994;15:74–9.
[25] Ahn S, Monafo W, Mustoe T. Topical silicone gel for the prevention and treatment of hypertrophic scar. Arch Surg 1991;126:499–504.
[26] Shin T, Bordeaux JS. The role of massage in scar management. Dermatol Surg 2012;38:414–23.

Please cite this article in press as: Anthonissen M, et al. The effects of conservative treatments on burn scars: A systematic review. Burns (2016), http://dx.doi.org/10.1016/j.burns.2015.12.006

[27] Melzack R, Wall P. Pain mechanism: a new theory. Surv Anesthesiol 1967;11:89–90.
[28] Anzarut A, Olson J, Singh P, Rowe BH, Tredget EE. The effectiveness of pressure garment therapy for the prevention of abnormal scarring after burn injury: a meta-analysis. J Plast Recontr Surg 2009;62:77–84.
[29] Kim S, Choi TH, Liu W, Ogawa R, Suh JS, Mustoe TA. Update on scar management: guidelines for treating Asian patients. Plast Reconstr Surg 2013;132:1580–9.
[30] Van Den Kerckhove E, Fieuws S, Massagé P, Hierner R, Boeckx W, Deleuze J-P, et al. Reproducibility of repeated measurements with the Kikuhime pressure sensor under pressure garments in burn scar treatment. Burns 2007;33:572–8.
[31] Van den Kerckhove E, Stappaerts K, Boeckx W, Van den Hof B, Monstrey S, Van der Kelen A, et al. Silicones in the rehabilitation of burns: a review and overview. Burns 2001;27:205–14.
[32] Monstrey S, Middelkoop E, Vranckx JJ, Bassetto F, Ziegler UE, Meaume S, et al. Updated scar management practical guidelines: non-invasive and invasive measures. J Plast Reconstr Aesthet Surg 2014;67:1017–25.
[33] Costa M, Peyrol S, Pôrto C, Comparin J, Foyatier L, Desmoulière A. Mechanical forces induce scar remodeling. Am J Pathol 1999;155:1671–9.
[34] Kischer C, Shetlar M, Shetlar C. Alteration of hypertrophic scars induced by mechanical pressure. Arch Dermatol 1975;111:60–4.
[35] Hosoda G, Holloway GA, Heimbach DM. Laser Doppler flowmetry for the early detection of hypertrophic burn scars. J Burn Care Rehabil 1986;7:496–7.
[36] Leung KS, Sher A, Clark JA, Cheng JC, Leung PC. Microcirculation in hypertrophic scars after burn injury. J Burn Care Rehabil 1989;10:436–44.
[37] Kischer CW, Thies ACCM. Perivascular myofibroblasts and microvascular occlusion in hypertrophic scars and keloids. Hum Pathol 1982;13:819–24.
[38] Kischer CW, Shetlar MR, Chvapil M. Hypertrophic scars and keloids: a review and new concept concerning their origin. Scan Electron Microsc 1982;4:1699–713.
[39] Friedstat J, Hultman C. Hypertrophic burn scar management: what does the evidence show? A systematic review of randomized controlled trials. Ann Plast Surg 2014;72:S198–201.
[40] Suetake T, Sasai S, Zhen Y, Tagami H. Effects of silicone gel sheet on the stratum corneum hydration. Br J Plast Surg 2000;53:503–7.
[41] Anthonissen M, Daly D, Fieuws S, Massage P, Van Brussel M, Vranckx J, et al. Measurement of elasticity and transepidermal water loss rate of burn scars with the Dermalab. Burns 2013;39:420–8.
[42] Klotz T, Kurmis R, Munn Z, Heath K, Greenwood JE. The effectiveness of moisturizers for the management of burn scars following severe burn injury: a systematic review protocol. JBI Database Syst Rev Implement Rep 2014;12:212–20.

Please cite this article in press as: Anthonissen M, et al. The effects of conservative treatments on burn scars: A systematic review. Burns (2016), http://dx.doi.org/10.1016/j.burns.2015.12.006