Physical Therapy and Rehabilitation
ISSN 2055-2386 | Volume 2 | Article 2

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Review Open Access

Post-surgical scar assessment in rehabilitation: a systematic review

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Abstract

Manual therapies are frequently recommended to improve post-surgical scar pliability, e.g., its elasticity and glide capacity with respect to the underlying tissue. A significant percentage of scars are pathological, causing pain, functional/psychological disorders, or cosmetic damage. Hence, early identification of a pathological post-surgical scar is crucial for prompt treatment so as to optimize and evaluate outcome. Scar assessment tools provide data on objective parameters as the basis for planning treatment. While the published literature contains many reviews on validated tools for post-surgical scar assessment, none specifically analyzes tools for use in the rehabilitative setting. The aim of this focused review was thus to illustrate the tools-instruments, scales and questionnaires-validated to assess post-surgical scar pliability in rehabilitation. A literature search was conducted on articles published in journals indexed by PubMed before October 15, 2014. The literature search produced 72 papers, 6 of which met our inclusion criteria. These 6 articles deal with the validation of 5 different tools to assess post-surgical scar. Three are devices aimed to assess different pliability characteristics: Adheremeter (degree of scar adherence), Cutometer (elasticity), and Tissue Ultrasound Palpation System (scar thickness). The other two are rating scales developed for general scar assessment (Vancouver Scar Scale, and Patient and Observer Scar Assessment Scale). As the efficacy of manual therapy on post-surgical scar is still debated, it is desirable that in the future increasing use be made of validated tools as outcome measures of the rehabilitation treatment.

Keywords: Measurement, skin, massage, manual therapy

Introduction

Scar is the result of the healing process of any kind of skin wound, linear or punctiform. A significant percentage of scars (38-70%, depending on the study) results in a pathological condition, i.e., causing pain, functional and psychological disorders, or cosmetic damage [1-4]. Manual therapies are frequently recommended as a primary treatment to improve scar cosmesis [5], and are aimed at improving both scar elasticity and 'glide' capacity with respect to the underlying tissue [6]. Massage therapy increases range of motion, reduces scar-related pain and itching, alleviates patients' anxiety and improves their mood and mental status [4].

Massage causes mechanical disruption of fibrotic tissue increasing the scar pliability [5]. Pliability can be defined as the mechanical property of the skin's firmness and extensibility that reflects both the morphological and physiological properties of the scar [7]. Pliability is a collective term referring to many different scar characteristics such as 'elasticity', 'stiffness', or 'adherence' [8,9]. Early identification of a pathological post-surgical scar is crucial in order to start treatment promptly so as to obtain an optimal outcome. Scar assessment tools provide data on objective parameters so that treatment can be planned accordingly [10]. The demonstration of sound psychometric properties in these measures (validation) is essential so that clinicians know they

 doi: 10.7243/2055-2386-2-2

can rely on data as an accurate and meaningful indicator of the treatment outcome, and thus a key factor in improving decision making in clinical practice [11]. Validation is a process aimed at assessing the psychometric characteristics of an assessment tool, in particular its validity and reliability. Validity concerns the extent to which an instrument measures what it is intended to measure. Reliability is the degree to which a measurement is free from error, i.e., the degree to which the observed score is 'true'.

In the literature many reviews on validated tools-devices and rating scales-for scar assessment have been published [1,3,10,12,13], but to our best knowledge there are none specifically analyzing those used for post-surgical scar assessment in the rehabilitation setting. The aim of this focused review was thus to illustrate the tools-instruments, scales and questionnaires-validated to assess post-surgical scar pliability for use in rehabilitation.

Review

Search methodology

A literature search was conducted on articles published in journals indexed by PubMed before October 15, 2014. **Figure 1** presents a flow chart of the article search with the key words used. In line with our search strategy, we selected only research papers published in English. The papers identified by the search were screened (full text) by two independent reviewers (expert in both the reviewing process and scar therapy) to identify those that met the selection criteria. We excluded reviews, case reports and papers dealing with validation studies of assessment tools not relevant to the rehabilitation of patients affected by post-surgical scar (e.g., papers on burn scars, on efficacy of therapeutic modalities, and on scar biology).

Results

The literature search produced 72 papers, 6 of which met the inclusion criteria for our review (**Figure 1** and **Table 1**). These 6 articles [14-19] dealt with the validation of 5 different tools to assess post-surgical scar. Three were devices assessing different pliability characteristics, the other two were rating scales developed for general scar assessment.

Devices

Adheremeter

The Adheremeter was designed to measure adherence of postsurgical scar, defined as the restriction of scar mobility with respect to underlying tissue at the point of worst adherence when stretched in four orthogonal directions [14]. It is an easy-to-use instrument of ergonomic shape, consisting of 9 concentric rings with radii of 1, 2, 4, 6, 8, 10, 12, 14, and 15 mm, respectively (**Figure 2**), printed on flexible transparent copier film to ensure maximum adaptability to different anatomical surfaces. The Adheremeter must be positioned so that the rings are centered on the worst adherent point. Scar is stretched in four orthogonal directions. For each traction, the rater reads on the Adheremeter the position of the worst adherent point at the maximal excursion. The four measurements, taken both for the scar and for the normal contralateral skin, are used to obtain two indices of the adherence's surface mobility: for the scar (SM_A) and for the normal contralateral skin (SM_N). The score of both SM_A and SM_N is obtained calculating the area of

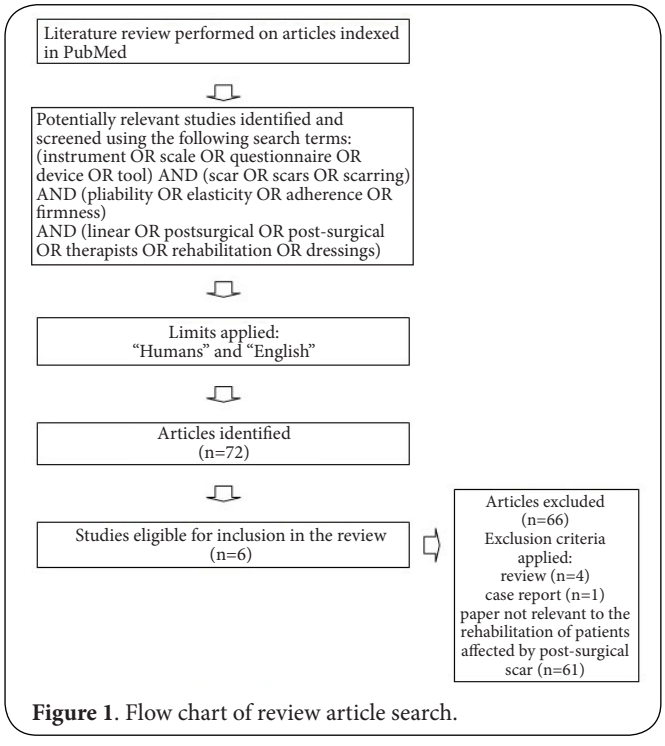

Figure 1. Flow chart of review article search.

Figure 2. Image of the Adheremeter device.

doi: 10.7243/2055-2386-2-2

Table 1. Research papers selected by the search.

Study	Scars	Sample size	Assessment Tool	Reliability (ICC)	
				Intra-rater	Inter-rater
Ferriero et al., 2010 [14]	Orthopedic surgery	25	Adheremeter	>0.96	>0.87
Rennekampff et al., 2006 [15]	Skin grafting	33	Cutometer	N/A	N/A
Lau et al., 2005 [16]	Miscellaneous conditions	100	TUPS	>0.98	0.84
Truong et al., 2005 [17]	Breast cancer surgery	212	VSS	N/A	0.78
Van de Kar et al., 2005 [18]	Surgery	100	POSAS	0.94	0.88
Van der Wal et al., 2014 [19]	Miscellaneous conditions	1070	POSAS	N/A	N/A

ICC: Intra-class correlation coefficient; TUPS: Tissue Ultrasound Palpation System; VSS: Vancouver Scar Scale; POSAS: Patient and Observer Scar Assessment Scale

the quadrilateral whose diagonals, which are orthogonal to each other, are the side-to-side and rostro-caudal landmark maximal excursions. The two indices are used to calculate an index of adherence severity (AS) as follows: $AS=SM_A/SM_N$. The AS value thus calculated ranges from 0 to 1, where 0 represents scar immobility in at least one diagonal (side-to-side and/or rostro-caudal), and 1 represents completely normal scar mobility.

Cutometer

The Cutometer (Courage and Khazaka Electronic GmbH, Köln, Germany) is a non-invasive electronic skin elasticity meter. It measures the skin deformation in millimeters during a controlled vacuum. Vacuum suction is applied perpendicularly to the skin surface to evaluate the viscoelastic scar properties. Measurement is made in the center of the region of interest. The Cutometer is equipped with measuring probes of different sizes, according to the different needs. The probe proposed to assess scar elasticity has a 6 mm opening to deform by suction deep layers of the skin [15]. The vacuum load of 500 mbar is used on the skin surface for a period of 1 s, followed by 1 s of normal pressure.

Tissue ultrasound palpation system

The Tissue Ultrasound Palpation System (TUPS, Biomedical Ultrasonic Solutions, Hong Kong) is a portable ultrasound machine developed to measure tissue thickness. It has been validated for soft tissue evaluation, including post-surgical scars [16]. It is equipped with a pen-size palpation probe, which consists of an ultrasound transducer and a load cell. The ultrasound transducer emits ultrasound waves to measure the whole scar thickness, while the load cell measures the load applied on the probe. The probe used for the measurement of surgical scars has a diameter of 3 mm and works at a frequency of 10 MHz, so enabling a more localized measurement at higher resolution.

Rating scales

Vancouver scar scale

The Vancouver Scar Scale (VSS) is the most widely used outcome scale for scars [1]. Four physical characteristics are rated: vascularity, pigmentation, height, and pliability. Each variable includes ordinal subscales that are summed to obtain a total score ranging from 0 to 13, with 0 representing normal skin. Different weight is given to each item (e.g., the pliability subscale score ranges from 0 to 5). Scar characteristics are defined not only by a numerical score, but also by descriptors to increase the potential for objective rating and facilitate the training process for observers. Although the literature on VSS focuses predominantly on burn scars, it has been validated also to rate postsurgical scars [17].

Patient and observer scar assessment scale

The Patient and Observer Scar Assessment Scale (POSAS v2.0) is a more recent scale with respect to the VSS [1]. It is composed of two distinct measurement tools: the Patient Scar Assessment Scale (PSAS), completed by the patient, and the Observer Scar Assessment Scale (OSAS), completed by the clinician. The PSAS consists of six items: pain, itching, color, stiffness, average thickness of the scar edge and surface irregularities. The OSAS investigates six scar features: vascularity, pigmentation, average thickness of the edge, relief, pliability and surface area of the scar. The total score for each scale ranges from 6 (=best, i.e., similar to normal skin) to 60 (=worst, i.e., scar very different from normal skin). In addition, the clinician and patient may express their opinion on the overall appearance of the scar, with a score from 0 (=similar appearance to healthy skin) to 10 (=worst possible appearance). The POSASv2.0 is available in English and Dutch language.

Discussion

Scar assessment is part of the ordinary evaluation of patients requiring rehabilitation after surgery. Its efficacy is based on the use of validated tools, fundamental to ensure reliable outcome measurements. This is the first review illustrating what validated tools for post-surgical scar assessment are available for researchers and clinicians working in a rehabilitative setting. Our literature search identified a small group of validated devices and rating scales. The screened devices are tools developed to measure specific scar characteristics

such as adherence, elasticity, and thickness.

Scar adherence is defined as the failure of the tissues to successfully establish independent layering [20]. It may produce several clinical problems, limiting range of motion and muscular strength, and altering the local proprioceptive input [1]. Adherent scars can be assessed by simple manual evaluation [21], or using the Adheremeter [14]. This free, non-electronic device has been defined as "a welcome simplistic device for examining the tension component of pliability with relation to adherence" [9]. The Adheremeter has been validated in patients after orthopedic surgery [14]. The two Adheremeter indexes of scar mobility showed good-to-excellent intra-rater and inter-rater reliability (ICC>0.87), correlated moderately with the VSS, and were able to detect changes after rehabilitation [14].

Elasticity can be instrumentally measured using the Cutometer [15]. This electro-medical device allows one to calculate a large battery of parameters including the passive reaction of the skin to force, its ability to return to its original state, or the viscoelastic and elastic recovery. In the paper selected by this review, the Cutometer was used to assess donor site wounds [15]. Some Cutometer parameters were able to detect a significant decrease in viscoelastic measurements in comparison with normal skin; however, no significant correlation between Cutometer measurements and the subjective pliability assessment of the VSS was found [15].

Scar thickness is a pathological aspect of hypertrophic scarring [1]. Ultrasonography is the most accurate and reproducible method available to measure the overall thickness above and below the skin surface, while the protruding part can be measured with a ruler. TUPS is an ultrasound measurement system validated for post-surgical hypertrophic scar assessment [16]. It showed a high test-retest and intra-rater reliability (ICC>0.84), good correlation with an ultrasound skin scanner, and a moderate correlation with the VSS.

Among the rating scales currently available, the POSAS can be considered the most complete, in particular because it takes into consideration the patient's judgment, but the VSS remains the most widely used scar-assessment instrument [17]. In fact, in all the previous papers aimed at validating devices the VSS was considered as the main variable of interest for the validity analysis. The VSS has been validated in patients after breast cancer surgery [17]. It had acceptable internal consistency and significant inter-rater reliability, and correlated significantly with an overall patient satisfaction scale (only in breast-chest wall scars, not axillary scars). POSAS is the only frequently used instrument for scar assessment besides the VSS [19]. This review found two papers on POSAS. The first paper [18] assessed a large sample of patients with linear scars. The scale showed good internal consistency and inter-rater reliability, and the two parts (observer and patients) demonstrated good agreement. The second paper [19] assessed some psychometric characteristics of the observer portion using Rasch analysis, a statistical approach based on a probabilistic model. Results gave valuable insights into the psychometric properties of this questionnaire, suggesting areas for future improvement.

The present review has two main limitations, firstly that the search was based on a restricted number of keywords and, secondly, that only the PubMed database was screened. Other medical libraries exist, but PubMed is one of the largest and best regarded, and free biomedical databases are available.

Conclusions

This review highlights the availability of different devices and scales validated for the assessment of post-surgical scars. Some of these instruments, i.e., the Adheremeter, VSS and POSAS, find easy application in a rehabilitative setting in that they are free and quick assessment tools. Cutometer and TUPS are two devices that can be considered as useful to measure specific objective characteristics of post-surgical scars. Considering that the efficacy of manual therapy for post-surgical scar is an issue still under debate, it is desirable that in the future increasing use be made of validated tools as outcome measures of the rehabilitation treatment.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Authors' contributions	GF	SDC	AF	LS	EB	FS	SV
Research concept and design	✓	--	--	✓	✓	--	✓
Collection and/or assembly of data	--	✓	✓	--	--	✓	--
Data analysis and interpretation	✓	--	--	✓	✓	--	--
Writing the article	--	✓	✓	--	--	✓	--
Critical revision of the article	✓	--	--	✓	✓	--	✓
Final approval of article	✓	✓	✓	✓	✓	✓	✓
Statistical analysis	--	✓	✓	--	--	✓	--

Publication history

Editor: Gordon John Alderink, Grand Valley State University, USA.
Received: 18-Jan-2015 Final Revised: 25-Mar-2015
Accepted: 10-Apr-2015 Published: 16-Apr-2015

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Citation:
Ferriero G, Carlo SD, Ferriero A, Salgovic L, Bravini E, Sartorio F and Vercelli S. **Post-surgical scar assessment in rehabilitation: a systematic review**. *Phys Ther Rehabil*. 2015; **2**:2.
http://dx.doi.org/10.7243/2055-2386-2-2