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...
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_s) and for the normal contralateral skin (SM_n). The score of both SM_s and SM_n is obtained calculating the area of...
Table 1. Research papers selected by the search.

| Study                          | Scars           | Sample size | Assessment Tool | Reliability (ICC) Intra-rater | Reliability (ICC) Inter-rater |
|-------------------------------|-----------------|-------------|-----------------|------------------------------|------------------------------|
| Ferriero et al., 2010 [14]    | Orthopedic surgery | 25          | Adherometer     | >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

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 postsurgical 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 | - | ✓ | ✓ | - | - | - | - |

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