burns 43 (2017) 993–1001

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Ultrasound is a reproducible and valid tool for measuring scar height in children with burn scars: A cross-sectional study of the psychometric properties and utility of the ultrasound and 3D camera

M. Simons [a,b,*], E. Gee Kee [a,b], R. Kimble [b,c,d], Z. Tyack [b]

[a] Department of Occupational Therapy, Lady Cilento Children's Hospital, 501 Stanley St, South Brisbane, Queensland 4101, Australia
[b] Centre for Children's Burns and Trauma Research, Child Health Research Centre, Level 7, Centre for Children's Health Research, 62 Graham St, South Brisbane, Queensland 4101, Australia
[c] Department of Paediatric Surgery, Urology, Neonatal Surgery, Burns and Trauma, Lady Cilento Children's Hospital, Brisbane, Queensland 4101, Australia
[d] School of Medicine, The University of Queensland, St Lucia, Queensland 4067, Australia

ARTICLE INFO

Article history:
Accepted 24 January 2017

Keywords:
Cicatrix
Burn scar thickness
Outcome measure
Ultrasound
Pediatric

ABSTRACT

Objective: The aim of this study was to investigate the reproducibility and validity of measuring scar height in children using ultrasound and 3D camera.

Method: Using a cross-sectional design, children with discrete burn scars were included. Reproducibility was tested using Intraclass Correlation Coefficient (ICC) for reliability, and percentage agreement within 1mm between test and re-test, standard error of measurement (SEM), smallest detectable change (SDC) and Bland Altman limits of agreement for agreement. Concurrent validity was tested using Spearman's rho for support of pre-specified hypotheses.

Results: Forty-nine participants (55 scars) were included. For ultrasound, test-retest and inter-rater reproducibility of scar thickness was acceptable for scarred skin (ICC=0.95, SDC=0.06cm and ICC=0.82, SDC=0.14cm). The ultrasound picked up changes of <1mm. Inter-rater reproducibility of maximal scar height using the 3D camera was acceptable (ICC=0.73, SDC=0.55cm). Construct validity of the ultrasound was supported with a strong correlation between the measure of scar thickness and observer ratings of thickness using the POSAS (ρ=0.61). Construct validity of the 3D camera was also supported with a moderate correlation (ρ=0.37) with the same measure using maximal scar height.

Conclusions: The ultrasound is capable of detecting smaller changes or differences in scar thickness than the 3D camera, in children with burn scars. However agreement as part of reproducibility was lower than expected between raters for the ultrasound. Improving the accuracy of scar relocation may go some way to address agreement.

* *Corresponding author at*: Department of Occupational Therapy, Lady Cilento Children's Hospital, 501 Stanley St, South Brisbane, Queensland 4101, Australia.
E-mail addresses: Megan.Simons@health.qld.gov.au (M. Simons), Emma.GeeKee@health.qld.gov.au (E. G. Kee), royk@uq.edu.au (R. Kimble), z.tyack@uq.edu.au, zephanie.tyack@gofarm.com.au (Z. Tyack).
http://dx.doi.org/10.1016/j.burns.2017.01.034
0305-4179/

1. Introduction

With mortality rates after burn declining, the greatest burden to burn centres is scarring [1–3]. Both adults and children with burns have reported the management of burn scar symptoms, both sensory and physical, as most central to their health-related quality of life [4]. It remains difficult to predict the extent of scar formation, so preventative interventions are generally routine practice [5,6]. In the drive towards one global standard for burn rehabilitation, there is agreement amongst burn professionals that improvement in the measurement of the effectiveness of burn scar interventions is of benefit [5]. Thus, the accurate measurement of scar outcomes is of critical importance.

Scar thickness, when examined alongside pliability, erythema and pigmentation, has been identified as the characteristic that most clearly distinguished normal scar and normal skin from hypertrophic scars across 12 months [7]. Scar thickness has been included in scar rating scales [8–11] and used as an outcome measure to evaluate the effectiveness of scar interventions [12–14]. Similarly, devices such as high frequency ultrasonography have been used to provide a quantitative assessment measure of scar thickness when evaluating burn scar interventions in children [15,16]. The three-dimensional (3D) stereophotogrammetry camera has been used to measure maximum and minimum burn scar height in adults [17] to date. However, there has been limited empirical testing to date of the ability of these tools to measure changes in burn scar thickness [18]. Measurements of reproducibility are required to determine the suitability of the measure for determining changes in scar height over time [19,20], which is an important consideration when evaluating the effectiveness of burn scar interventions.

In children, investigation of the reliability and validity of high frequency ultrasound and 3D camera to measure scar height is limited. While an unspecified number of children were included (mean age 42.2 ± 28.3 years, range 13 months to 80 years) in the investigation of the reliability of a high frequency ultrasound (Tissue Ultrasound Palpation System) the majority of scarring arose from trauma and surgical sources [21]. Reliability was high for inter-rater (ICC = 0.84) and excellent for intra-rater (ICC = 0.98). Reliability of the 3D camera was excellent when measuring burn wound area in children (ICC = 0.99) [22], but required relatively flat areas with well-defined borders for clinical utility to be supported when measuring scar height in adults [17]. Intra-rater reliability for maximum and minimum scar height measurement was acceptable for immediate test-retest only (ICC = 0.85, 0.86 respectively) using the 3D camera in adults with burn scars. However the smallest detectable change for maximum and minimum scar height was 2.66 mm and 1.16 mm respectively [17], which are larger than the 1 mm differences in the scale points on a rating scale such as the Vancouver Scar Scale [10]. The high frequency ultrasound device (BT12 Venue 40MSK) measured changes of 1 mm in thickness in partial thickness burns that healed spontaneously in children [15]. However this device has not yet been established as suitable for measuring scar height.

Consistent application of valid, reproducible and clinically applicable objective measures of scar features will improve our understanding of which interventions are the most effective to modify scarring. Therefore, the aim of this study was to investigate the reproducibility and validity of the ultrasound and 3D camera for measuring scar height in children with burn scars.

2. Method

2.1. Study design

A cross-sectional design was used to investigate the reproducibility and validity of two commercially available devices (high frequency ultrasound and 3D camera). Children with burn scars were recruited from a quaternary, metropolitan-based, paediatric hospital in Queensland, Australia. The study received ethical clearance from the Metro South Human Research Ethics Committee, Brisbane (HREC/12/QPAH/595). The study will be reported according to STROBE guidelines [23].

2.2. Participants

Children were included in this study if they had discrete burn scar/s and were attending the burns outpatient clinic at the participating hospital between 2014 and 2015. Up to two scars per person were included. There was no restriction for participation based on the patient's age, gender, skin type as defined by the Fitzpatrick scale, or burn severity based on burn depth and percent total body surface area. Burn scars on fingers or toes were excluded as previous difficulties have been documented mapping 3D photographs on very curved areas and using the ultrasound on these anatomical sites due to very thin skin and the small size of fingers and toes in young children [17]. Participants were also excluded if there was no informed consent, the identified scar was not the result of a burn, the child or caregiver had a cognitive or intellectual impairment, were currently involved with the Department of Communities, Child Safety and Disability Services (child protection) or were non-English speaking.

2.3. Procedure

Children meeting the inclusion criteria were approached on presentation to the hospital for scar treatments or follow-up appointments with all measurements and questionnaires completed face-to-face in the same hospital setting. A sample size of a minimum of 50 scar sites was sought [24]. To assess the reproducibility of the high frequency ultrasound and 3D camera, two occupational therapists were nominated as raters. Each rater was experienced in the use of the ultrasound and 3D camera in the clinical setting. The two raters completed and discussed findings from all measures on two participants prior to data collection commencing. Rater 1 measured the scar area twice for calculation of intra-rater and test-retest reliability. Following informed consent from the caregiver and verbal assent from the child (if aged over 4 years), the scar area was identified. If a child had multiple scar sites, rater 1 identified one or two scar areas to measure with the input of the child and caregiver, which