Multidimensional aspects of burn wound treatment

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Part IV

Scar formation: patterns and predictors

Chapter 9

Patterns and predictors of burn scar outcome in the first 12 months post-burn: the patient's perspective

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ABSTRACT

Objective: This study aimed to provide insight into the patterns and factors that predict burn scar outcomes at 3, 6 and 12 months post-burn.

Methods: The Patient and Observer Scar Assessment Scale (POSAS) was used to assess the scar formation of each patient. Structural equation modelling was used. The predictor variables used in this study were sex, three age categories, TBSA, depth of the wound and cause of the burn.

Results: The POSAS patient total and individual item scores demonstrated a statistically significant decrease in the first 12 months post-burn, except for the relief item. Male patients had a lower total and items scores (better scar quality) for pain and pruritus compared with female patients. Full thickness burns had a higher scores for pruritus, pliability, thickness and relief compared to the partial-thickness burns. Ages younger than 5 years, higher TBSA values and flame burns were predictors of various POSAS items at 3 and 6 months post-burn.

Conclusion: The POSAS patient total and individual item scores demonstrated a statistically significant improvement in the scar quality in the first 12 months post-burn, except for the relief. Sex, age, depth of the wound, the percentage of TBSA and flame burns were predictors of various POSAS patient items at 3, 6 and 12 months post-burn.

INTRODUCTION

Burn scars have extensive impacts on burn patients in terms of quality of life, functional impairment and physiological problems.(1-3) Thus, the optimal management of burn scars requires more insight into the factors that influence the severity of burn scars.

To date, sex, age, skin type, location, bacterial colonisation, time to wound healing, type of graft, multiple surgical procedures, burn severity and the skin being subjected to stretching have been found to be risk factors for hypertrophic scarring.(4-8) The impacts of burn scars not only entail the appearance of the scar but also involve of its accompanying symptoms. Up to 47% of patients experience pain that is associated with their burn scars.(9) In addition, pruritus was found to still be present in 67% of the burn patients at two years post-burn.(10) It should be noted that different burn scar assessment strategies were used in these studies, and these studies were often limited by the lack of an appropriate tool for evaluating scar outcomes.

Currently, the Patient and Observer Scar Assessment Scale (POSAS) is widely used to assess scar quality.(11) The POSAS consists of observer and patient components and has been found to be a reliable and valid instrument for the assessment of burn scars. (12, 13) The POSAS patient scale by Draaijers et al. (version 1.0) incorporates scores for the following six items by using a 10-point rating scale: pain, itch, color, pliability, thickness and relief. (12, 14) A high score indicates a worse scar quality. There is a paucity of research investigating the changes in the POSAS scores after burns.(15) Van der Wal et al. described that full thickness wounds and a higher percentage of TBSA were significant predictors of a higher POSAS score, whereas the aetiology and age of the patient had no influence on the scar quality.(16) In addition, POSAS assessment a three months post-burn found to be predictive of final scar quality at twelve months post-burn.(17)

The purpose of the present study was to describe the influence of predictors on changes in POSAS patient scores at 3, 6 and 12 months post-burn.

MATERIALS AND METHODS

Recruitment and study population

This retrospective study was performed at the burn centre outpatient clinic at the Red Cross Hospital, Beverwijk in the Netherlands between June 2004 and December 2009. This study was conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The POSAS questionnaire is a standard part of each routine

follow-up visit of each of the burn patients in the outpatient clinic at 3, 6 and 12 months at our specialized burn centre. The data of the patients who were admitted to the burn centre and who were subsequently seen at the outpatient clinic at 3, 6 and 12 months post-burn were included in the analysis. In this consecutive sample, the patients who participated in clinical trials for wound or scar treatments were excluded from the study. The parents or caregivers were asked to fill in the POSAS patient component for patients who were under the age of 5 years. Baseline characteristics such as sex, age at the time of burn, the percentage of total body surface area (TBSA), burn depth (partial or full thickness) and the cause of the burn wound (flame or scald) were collected. At our institution, patients with full-thickness burns were operated (skin grafting). Mixed burns (partial and full-thickness) were conservatively treated for approximately 10 to 14 days. Burn wounds of > 3 cm^2 that were not yet healed, were considered for skin grafting procedures. Partial-thickness burns were treated with topical antiseptics or hydrofibre dressings. This treatment algorithm was chosen because wound healing that takes more than three weeks to complete, is considered to be a risk factor for hypertrophic scar formation.(18) Patients were categorized into the following three age-groups: < 5 years, 5 - 18 years and > 18 years. The cut-off value of 5 years was chosen because of two reasons. First, the epidemiology of burn wounds tends to be different between children < 5 years and older children. In general, scald burns were more common in children who were younger than 5 years compared with older children.(19, 20) Second, the POSAS patient scores of this age category were completed by the caregivers, which may influence the outcomes compared with older children who completed the POSAS patient scores on their own. The study location at three months post-burn was defined as the most apparent part of the scar according to the patient. Standard treatment consisted of silicones or pressure garments depending on the location and scar activity. If there was a significant functional impairment during ADL, then there was an indication of reconstruction surgery during the first 12 months post-burn. After 12 months post-burn, an operation was indicated for both functional impairment and esthetical reasons.

The POSAS

To the best of our knowledge, there is conflicting data in the literature concerning the analysis of the POSAS patient scores. Van der Wal et al. found that the POSAS patient questionnaire was unidimensional. Therefore, the individual and sum of the items of the POSAS patient scores could be used for statistical analysis.(21) Conversely, de Jong et al. found that the POSAS patient questionnaire was multidimensional. Therefore, the only individual POSAS patients scores could be used for statistical analysis.(13) In this study, we used both the individual and sum of the POSAS patient scores for statistical analysis. If the patient was unable to answer the questionnaire, e.g. in the case of children < 5 years or in the case of mentally impaired patients, then the caretaker was asked to score the items.

Study model and statistical analyses

Structural equation modelling (SEM) was performed using the IBM SPSS statistical package AMOS[TL] 24.(22) We applied a latent growth curve model (LGM), which was a special application of the SEM with several advantages. Latent growth curve modelling in AMOS was able to accommodate irregularly spaced measurements at the three time points (3, 6 and 12 months post-burn) in our data. (23) In addition, the use of LGM made it possible to assess the fit of the model to the data and to effectively compute the maximum likelihood estimates in our dataset, which was not completed at all three of the time points (Appendix B). The Inter-individual differences in the changes over time were assessed, and group-level statistics such as the mean change rates and mean intercepts were provided. The LGM accounts for the of change (slope curve analysis) at the individual level (patient) and at the group level (for instance, the depth of the burn wound, sex, etc.). The fit of the LGM was tested. The absolute and comparative fit indices were calculated.

The following predictor variables were entered into the models: sex, age < 5 years, age 5 - 18 years and age > 18 years, the percentage of TBSA, depth of the wound and cause of the burn. Our model was based on our earlier study that used the POSAS patient scale to study the influence of time-invariant predictors (such as sex, the percentage of TBSA, wound depth and age categories) on the POSAS scale in the same group of patients.(16) The three different intercept estimates represented the patients' total scores at 3, 6 or 12 months. The time moment of the intercept was dependent on how the time values were coded (0, 1, 3; –1, 0, 2 or –3, –2, 0). The slope estimates represented the patients' rates of change between 3, 6 and 12 months post-burn. Positive intercepts indicated higher POSAS scores at 3, 6 and 12 months post-burn, which thus indicated a worse scar quality compared to that of the reference group. Significant negative slopes in the POSAS scores indicated a slower rate of change in the presented predictor category compared to that in the reference category (for example, flame burns compared to the reference category scald burns).

The correlations between the intercepts and slopes were calculated. A positive value indicated a high initial score at 3 months post-burn with a greater rate of change, whereas a negative correlation indicated a high initial score at 3 months post-burn with a lower rate of change.

The LGM was investigated in a model for the total score and was individually investigated in a model for the six items that were incorporated in the POSAS patient scale, both with and without predictors. The intercept estimate can be interpreted as the influence of the predictors on the POSAS patient scores at 3, 6 and 12 months post-burn. The positive intercepts implied higher POSAS scores compared to the reference category. The slope estimate can be interpreted as the influence of the predictors on the changes in the POSAS scores over time. Positive slopes indicate higher degree of change over time compared to the reference category. An detailed description of the study model and statistical analyses can be found in Appendix D.

RESULTS

Baseline characteristics

A total of 284 children and 190 adult patients were included in this study. The patients' characteristics are shown in Table 1. There were no statistically significant differences in the total TBSA (p = 0.99, independent *t*-test), full-thickness burns (p = 0.30, independent *t*-test), or surgeries on the evaluated scars (p = 0.53, chi-square test) that were observed between the groups of patients who completed all three evaluations (n = 157) and the patients who completed one or two of the evaluations moments (n = 317).

Table 1. Patient characteristics.

Characteristic	< 18 years	≥ 18 years
Number of patients (%)	284 (60)	190 (40)
Sex, n (%)		
- Male	186 (64.5)	103 (54.2)
- Female	98 (34.5)	87 (45.8)
Age at burn, median in years (range)	2.5 (0.7 - 17.8)	43.2 (18.6 - 85.6)
TBSA, median (range)		
- Total	7 (0.5 - 76)	7.3 (0.5 - 85)
- Full thickness	1 (0.5 - 75)	3 (0.5 - 60)
Cause of the burn (%)		
- Scald	172 (60.6)	26 (13.7)
- (Flash)flame	70 (24.6)	115 (60.5)
- Contact	19 (6.7)	15 (7.9)
- Oil/ fat	20 (7.0)	27 (14.2)
- Chemical	0 (0)	6 (3.2)
- Electricity	3 (1.1)	0 (0)
- Other	0 (0)	1 (0.5)
Treatment of evaluated scar		
- Conservative treatment, n (%)	86 (30.3)	31 (16.3)
- Surgery (skin grafting), n (%)	198 (69.7)	159 (83.7)
Evaluated, n (%)		
- At 3 months post burn	224 (78.9)	135 (71.1)
- At 6 months post burn	205 (72.2)	122 (64.2)
- At 12 months post burn	156 (55.3)	76 (40.0)
Total evaluations, n (%)		
- One evaluation completed	76 (26.8)	81 (42.6)
- Two evaluations completed	101 (35.6)	71 (37.4)
- Three evaluations completed	97 (34.2)	38 (20.0)

TBSA: Total body surface area.

The fit indices for the different models

The fit indices for the different models are presented in Appendix B. The fit indices for the model with the total score and the six predictors (Appendix A) revealed the following results: The minimum discrepancy (CMIN) was 6.751 with 7 degrees of freedom (df) and a *p*-value of 0.455. The comparative fit index (CFI) was 1.00. The root mean square error of approximation (RMSEA) was 0.0001 with a confidence interval of 0.0001 - 0.055. These values of the fit indices agree with a good-to-perfect fit with the total score and the six predictors. All of the models that evaluated the six individual items had a perfect fit. The model with the total score without the six predictors had a moderate fit, and the models with the items of thickness or relief and without the six predictors had a poor fit.

Patterns of change in the POSAS patient scores

The parameter estimates for the intercept and slopes of the model that evaluated the separate total POSAS patient scale scores and the separate 6 items without the 6 predictors are shown in Table 2. The parameter estimates for the total POSAS scores obtained from the predictor models are presented in Table 2 and Appendix A. Pain had the lowest separate intercept score, which implied that pain had the lowest item score out of the six items in the POSAS at 3 months post-burn. The total score and all of the items (except relief) had significant negative slopes, which implied that the rates of change in the scores showed a decreasing trend. The covariances between the predictor variables of the total POSAS patient scale scores are shown in Appendix C.

Sex

Male patients had lower total POSAS patient scores at 3, 6 and 12 months post-burn, with no significant difference in the rate of change when compared to female patients.(Table 3) The male patients had lower pain scores at 3 and 6 months post-burn, with an equal rate of change compared to females. Men tended to have lower itch scores at 3 and 6 months post-burn. Nevertheless, the changes in the scores over time were comparable.(Table 4A) Male patients had higher POSAS scores for relief at 3 and 6 months post-burn, with lower pliability scores at 6 and 12 months post-burn. However, the changes in the scores were comparable to those observed in female patients.(Table 4B)

Table 2. Estimates of the intercepts, slopes and covariances between intercepts and slopes of the total scores and items pain, pruritus, color, pliability, thickness and relief without predictors.

POSAS patient scale	**Intercept**				**Slope**				**Covariances**			
	Estimate	**SE**	**CR**	***p***	**Estimate**	**SE**	**CR**	***p***	**Estimate**	**SE**	**CR**	***p***
Total score												
3 months	29.18	0.55	53.25	**< 0.001**	-2.02	0.25	-8.25	**< 0.001**	-2.86	4.56	-0.63	0.531
6 months	27.16	0.47	57.75	**< 0.001**					-1.13	2.94	-0.38	0.701
12 months	23.12	0.65	35.60	**< 0.001**					2.34	8.83	0.26	0.791
Items:												
Pain												
3 months	2.38	0.10	22.45	**< 0.001**	-0. 17		-4.26	**< 0.001**	-0.07	0.14	-0.47	0.637
6 months	2.21	0.09	25.01	**< 0.001**					0.01	0.09	0.07	0.942
12 months	1.87	0.11	16.75	**< 0.001**					0.15	0.27	0.55	0.581
Pruritus												
3 months	4.54	0.13	33.81	**< 0.001**	-0.49	0.06	-8.09	**< 0.001**	-0.67	0.26	-2.55	**0.011**
6 months	4.05	0.11	36.05	**< 0.001**					-0.10	0.18	-0.54	0.592
12 months	3.07	0.15	19.92	**< 0.001**					1.05	0.51	2.06	**0.039**
Color												
3 months	6.94	0.11	64.43	**< 0.001**	-0.54	0.06	-9.56	**< 0.001**	-0.52	0.21	-2.52	**0.012**
6 months	6.40	0.09	74.02	**< 0.001**					-0.17	0.14	-1.27	0.204
12 months	5.32	0.14	39.26	**< 0.001**					0.52	0.39	1.32	0.187

Table 2. Continued.

POSAS patient scale	Intercept				Slope				Covariances			
	Estimate	**SE**	**CR**	***p***	**Estimate**	**SE**	**CR**	***p***	**Estimate**	**SE**	**CR**	***p***
Pliability												
3 months	5.79	0.13	44.66	**< 0.001**	-0.47	0.07	-7.07	**< 0.001**	-0.40	0.30	-1.37	0.172
6 months	5.33	0.11	50.73	**< 0.001**					-0.10	0.19	-0.52	0.600
12 months	4.40	0.16	27.59	**< 0.001**					0.50	0.58	0.87	0.383
Thickness												
3 months	5.26	0.13	39.84	**< 0.001**	-0.31	0.06	-5.06	**< 0.001**	0.08	0.28	0.29	0.770
6 months	4.96	0.11	43.61	**< 0.001**					0.10	0.18	0.52	0.601
12 months	4.34	0.16	26.80	**< 0.001**					0.12	0.57	0.21	0.832
Relief												
3 months	5.08	0.13	39.10	**< 0.001**	-0.09	0.06	-1.34	0.179	-0.35	0.29	-1.19	0.236
6 months	5.00	0.11	47.33	**< 0.001**					-0.07	0.19	-0.37	0.715
12 months	4.82	0.16	30.83	**< 0.001**					0.48	0.57	0.85	0.397

SE: standard error, CR: critical ratio.

Wound depth

Patients with full thickness burns had higher POSAS patient total scores at 3 months post-burn and a lower rate of change during the first 12 months post-burn compared to patients with partial thickness burns. The total POSAS scores for full thickness and partial thickness burns showed no difference at 12 months post-burn.(Table 3) Pruritus scores at 3 months were significantly higher in patients with full thickness burns than those in patients with partial thickness burns. The rate of change in the pruritus scores was significantly lower in patients with full thickness burns.(Table 4A) Finally, patients with full thickness burns had significantly higher POSAS scores for pliability, thickness and relief at 3 and 6 months post-burn compared with patients with partial thickness burns.(Table 4B)

Age

There was no significant difference in the total POSAS scores between younger patients or patients who were older than 5 years. However, patients who were younger than 5 years had significantly lower pruritus scores at 12 months post-burn and lower rates of change compared to older patients.(Table 4A) Patients aged below 5 years had higher scar color, pliability and thickness scores at 3 and 6 months post-burn, while patients older than 18 years had a higher scar color scores at 12 months post-burn and a greater change in scores than the younger patients.(Table 4B) Patients older than 18 years had higher pain scores at 3, 6 and 12 months post-burn than younger patients, but groups of patients had equal rates of change.(Table 4A)

Aetiology and percentage of TBSA

The covariances between the predictor variables of the total POSAS patient score are shown in Appendix A and Appendix C. No effects of the percentage of TBSA or cause of burn were found on the total POSAS patient scale.(Table 3) Patients with flame burns generally had significantly higher color scores at 3 and 6 months post-burn.(Table 4A) Patients with a higher percentage of TBSA had higher POSAS score for relief at 3 and 6 months post-burn. (Table 4B) Pruritus scores at 6 and 12 months post-burn were higher in patients with a higher percentage of TBSA values.

Table 3. Regression weights and *p*-values of the POSAS patient scores and the predictors TBSA, burn depth, age category, sex and cause of burn.

POSAS patient scale total score					
Predictors		**Estimate**	**SE**	**CR**	***p***
Sex: male	Intercept at 3 months	-3.327	1.138	-2.922	**0.003**
	Intercept at 6 months	-3.204	0.973	-3.292	**< 0.001**
	Intercept at 12 months	-2.959	1.332	-2.222	**0.026**
	Slope	0.122	0.504	0.243	0.808
Depth: full thickness	Intercept at 3 months	3.543	1.283	2.762	**0.006**
	Intercept at 6 months	1.997	1.097	1.820	0.069
	Intercept at 12 months	-1.095	1.501	-0.730	0.466
	Slope	-1.546	0.568	-2.722	**0.006**
Age < 5 years	Intercept at 3 months	3.130	1.664	1.881	0.060
	Intercept at 6 months	1.673	1.423	1.176	0.240
	Intercept at 12 months	-1.242	1.942	-0.640	0.522
	Slope	-1.458	0.735	-1.984	**0.047**
Age > 18 years	Intercept at 3 months	0.649	1.443	0.450	0.653
	Intercept at 6 months	1.229	1.234	0.996	0.319
	Intercept at 12 months	2.388	1.689	1.414	0.157
	Slope	0.580	0.639	0.907	0.364
Cause: flame burns	Intercept at 3 months	1.006	1.490	0.675	0.499
	Intercept at 6 months	0.840	1.272	0.661	0.509
	Intercept at 12 months	0.509	1.719	0.296	0.767
	Slope	-0.166	0.651	-0.255	0.799
TBSA	Intercept at 3 months	0.024	0.044	0.552	0.581
	Intercept at 6 months	0.041	0.037	1.107	0.268
	Intercept at 12 months	0.076	0.051	1.486	0.137
	Slope	0.017	0.019	0.893	0.372

SE: standard error, CR: critical ratio. Reference categories were female sex, partial thickness burns, age 5 - 18 years, scald burns. TBSA was a continuous variable in the model.

Table 4A. Regression weights and *p*-values of the items pain, pruritus and color of the POSAS patient scale from the predictors TBSA, burn depth, age category, sex and cause of burn.

Items POSAS patient scale		**Pain**		**Pruritus**		**Color**	
Predictors		**Estimate**	***p***	**Estimate**	***p***	**Estimate**	***p***
Sex: male	Intercept 3 months	-0.730	**< 0.001**	-0.676	**0.015**	-0.181	0.419
	Intercept 6 months	-0.598	**< 0.001**	-0.614	**0.009**	-0.039	0.830
	Intercept 12 months	-0.335	0.124	-0.489	0.118	0.246	0.375
	Slope	0.132	0.117	0.062	0.611	0.143	0.217
Depth: full thickness	Intercept 3 months	0.125	0.572	0.756	**0.016**	0.249	0.324
	Intercept 6 months	0.090	0.631	0.374	0.156	0.100	0.624
	Intercept 12 months	0.019	0.939	-0.392	0.266	-0.200	0.524
	Slope	-0.035	0.708	-0.383	**0.005**	-0.150	0.250
Age < 5 years	Intercept 3 months	-0.070	0.807	0.069	0.866	1.031	**0.002**
	Intercept 6 months	-0.071	0.771	-0.316	0.355	0.660	**0.012**
	Intercept 12 months	-0.072	0.822	-1.084	**0.017**	-0.082	0.839
	Slope	0.000	0.997	-0.384	**0.031**	-0.371	**0.027**
Age > 18 years	Intercept 3 months	1.282	**< 0.001**	-0.480	0.175	0.008	0.978
	Intercept 6 months	1.330	**< 0.001**	-0.311	0.294	0.360	0.115
	Intercept 12 months	1.427	**< 0.001**	-0.009	0.983	1.065	**0.003**
	Slope	0.049	0.648	0.169	0.275	0.352	**0.016**
Cause: flame burns	Intercept 3 months	0.303	0.240	-0.065	0.858	0.951	**0.001**
	Intercept 6 months	0.313	0.150	-0.027	0.929	0.527	**0.025**
	Intercept 12 months	0.333	0.236	0.049	0.903	-0.320	0.371
	Slope	-0.010	0.926	0.038	0.810	-0.424	**0.004**
TBSA	Intercept 3 months	0.001	0.854	0.020	0.067	0.001	0.900
	Intercept 6 months	0.002	0.801	0.023	**0.011**	0.005	0.491
	Intercept 12 months	0.002	0.808	0.029	**0.016**	0.012	0.254
	Slope	0.000	0.948	0.003	0.506	0.004	0.405

Reference categories were female sex, partial thickness burns, age 5 - 18 years, scald burns. TBSA was a continuous variable in the model.

Table 4B. Regression weights and *p*-values of the items pliability, thickness and relief of the POSAS patient scale from the predictors TBSA, burn depth, age category, sex and cause of burn.

Items POSAS patient scale		**Pliability**		**Thickness**		**Relief**	
Predictors		**Estimate**	***p***	**Estimate**	***p***	**Estimate**	***p***
Sex: male	Intercept 3 months	-0.393	0.138	-0.136	0.617	-0.520	**0.051**
	Intercept 6 months	-0.545	**0.012**	-0.269	0.252	-0.435	**0.045**
	Intercept 12 months	-0.847	**0.011**	-0.537	0.114	-0.264	0.421
	Slope	-0.151	0.262	-0.134	0.294	0.085	0.528
Depth: full thickness	Intercept 3 months	1.151	**< 0.001**	0.797	**0.009**	1.076	**< 0.001**
	Intercept 6 months	0.682	**0.005**	0.463	**0.080**	0.863	**< 0.001**
	Intercept 12 months	-0.254	0.497	-0.204	0.595	0.438	0.238
	Slope	-0.468	**0.002**	-0.334	**0.020**	-0.213	0.162
Age < 5 years	Intercept 3 months	1.333	**< 0.001**	0.953	**0.016**	0.574	0.141
	Intercept 6 months	0.799	**0.012**	0.787	**0.022**	0.453	0.153
	Intercept 12 months	-0.267	0.580	0.453	0.360	0.209	0.662
	Slope	-0.533	**0.007**	-0.167	0.369	-0.122	0.536
Age > 18 years	Intercept 3 months	0.492	0.143	0.026	0.940	-0.031	0.928
	Intercept 6 months	0.307	0.264	0.018	0.951	0.147	0.592
	Intercept 12 months	-0.062	0.882	0.004	0.993	0.503	0.228
	Slope	-0.185	0.280	-0.007	0.964	0.178	0.299
Cause: flame burns	Intercept 3 months	0.277	0.425	-0.514	0.147	-0.025	0.942
	Intercept 6 months	0.318	0.262	-0.302	0.325	-0.153	0.589
	Intercept 12 months	0.400	0.349	0.123	0.780	-0.408	0.336
	Slope	0.041	0.813	0.212	0.196	-0.127	0.465
TBSA	Intercept 3 months	0.004	0.667	0.021	**0.042**	0.026	**0.010**
	Intercept 6 months	0.006	0.508	0.015	0.094	0.023	**0.006**
	Intercept 12 months	0.008	0.541	0.003	0.821	0.016	0.200
	Slope	0.001	0.827	-0.006	0.212	-0.003	0.517

Reference categories were female sex, partial thickness burns, age 5 - 18 years, scald burns. TBSA was a continuous variable in the model.

DISCUSSION

The change in the POSAS patient scale scores was studied between 3 and 6 months post-burn and between 6 and 12 months post-burn. The POSAS patient total score and all of the item scores showed a statistically significant decline in these two time periods, except for the relief item. The greatest decline was observed during the longer time period between 6 and 12 months post-burn. The pain item scale presented the lowest decline score, and the color item exhibited the highest decline score. Therefore, the pain and color items had the lowest and highest influences on the total POSAS score, respectively. The low pain scores could be the result of effective medication for pain and/or the result of real low pain values in patients after 3 months post-burn. The high color values represent the importance of color for the patient assessment of his or her scars. Patients with the highest total and item scores presented the lowest changes during the 3 and 6 months post-burn, thus leading to the lowest decline in the total score.

In our study, a strong effect of sex was observed on the total POSAS patient score. Male patients had a better scar quality, which was caused by lower score of pruritus and pain, as well as a better score for pliability and relief compared to the scar quality in female patients. Various studies have demonstrated higher pain-related symptoms in women compared with men.(24-26) Sex role beliefs, pain coping strategies, pain-related expectations and even hormonal factors may possibly explain the difference in pain experience between males and females.(27) In line with our study, two studies observed higher itch intensity scores in women compared to men, although this phenomenon is not well understood.(10, 28) Higher pliability and relief scores in the female group in our study could possibly be explained by the differences in body images between males and females. In general, women have a more negative body image compared to men.(29-31) Dyer et al. observed that women with scars that resulted from accidents or surgeries reported a more negative body image.(31)

Patients with full thickness burns had higher total POSAS scores, which were caused by higher scores for the pruritus, pliability, thickness and relief items. Other studies have also described higher itching scores for full thickness burns and grafted wounds.(10, 28, 32) An increase in both mediators and neuronal damage are thought to contribute to pruritus symptoms in full thickness burns.(33) In our study, pruritus diminished after 3 months post-burn; a finding that has been previously described in other studies.(10, 16) Higher POSAS scores for pliability, thickness and relief are explained by the loss of epidermal and dermal structures.

Previous studies have found that the age of the patient does not influence scar behavior. (6, 16, 34) Our results are consistent with these reports when considering the total POSAS score. However, this is not the case when looking at the separate items. Patients who were aged below 5 years had significantly higher scores for color, pliability and thickness at 3 and

6 months post-burn, and these patients also had significantly less pruritus at 12 months post-burn. The fact that caretakers completed the questionnaires for the patients under 5 years old may have contributed to the differences in the outcomes between the age groups. We did not find any studies that reported the influence of age on color change in burn scars.

Furthermore, it should be noted that different studies have described a negative association between age and hypertrophic scar formation.(35) This finding is supported by the decreased proliferation, reepithelization and inflammatory responses that are observed during wound healing, as well as the slower epidermal turnover and the different remodeling phase that are observed in aged individuals.(7, 35, 36) However, the present study did not investigate hypertrophic scar formation. Finally, patients who were above 18 years had higher pain scores at 3, 6 and 12 months post-burn compared to patients who were below 18 years.

The percentage of TBSA was a predictor for the pruritus, thickness and relief item scores. The effect of the percentage of TBSA on pruritus has been well described in various studies. However, there are conflicting data on the effect of the percentage of TBSA on the duration of pruritus. Van Loey et al. described a higher TBSA to be a risk factor for pruritus at 3 months post-burn.(10) The scar tissue modulation and nerve density which are thought to be highest in the first 6 months post-burn could explain this effect. However, in line with other studies, we found the effect of the percentage of TBSA to be significant even at 12 months post-burn.(28, 37) Furthermore, the effect of full thickness burns and the percentage of TBSA on itching is different than the effect of full thickness burns on pain. Pain scores were observed to be the lowest of all the scored items on the POSAS patient scale. This could be caused by a different mechanism or by a better treatment for pain.

Scald injuries are more often observed in patients who are under 5 years, whereas fire/flame burns are observed more often in older patients. Additionally, more males than females are admitted to burn centres. Full thickness burns and burns with a higher percentage of TBSA tend to occur more often in patients who are older than 18 years. Flame burns are more often deep dermal or full-thickness burns. Overall, our data are corroborated by the findings of various epidemiological studies.(19, 38)

Our study had several limitations. First, the age-related findings of the patients who were under 5 years should be interpreted with caution, given that the care givers completed the questionnaires. Second, no sample size calculation was performed, given the large number of included patients and given that the data were retrospectively collected. However, a sample size calculation could still be relevant, based on the amount of missing data. Third, the extent of the influence of the excluded patients on the results of the current study is unknown, because no data of the excluded patients were recorded. Fourth, there are conflicting data

on whether the POSAS score is a unidimensional instrument. Therefore, the scores of the individual items could be summed into a total score.(13, 21) In theory, the POSAS patient questionnaire is based on a formative model in which the individual items of the POSAS patient score are causal indicators of the scar quality. A formative questionnaire could consist of more than one dimension. Thus the individual items could be summed to a final score, for example as is done for the Apgar score. Finally, the included study predictors were obtained from the available literature, whereas no systematic search was performed. As a result, there may be predictors that are not included in the current study, which may be relevant in the context of changes in the POSAS scores at 3, 6 and 12 months post-burn.

CONCLUSION

This retrospective study, the POSAS patient total and individual item scores demonstrated a statistically significant improvement in the first 12 months post-burn, except for the relief item. Furthermore, sex, age, depth of the wound, percentage of TBSA and flame burns were predictors of various POSAS patient items at 3, 6 and 12 months post-burn. However, the effect of these predictors was not the same for the individual POSAS patient items.

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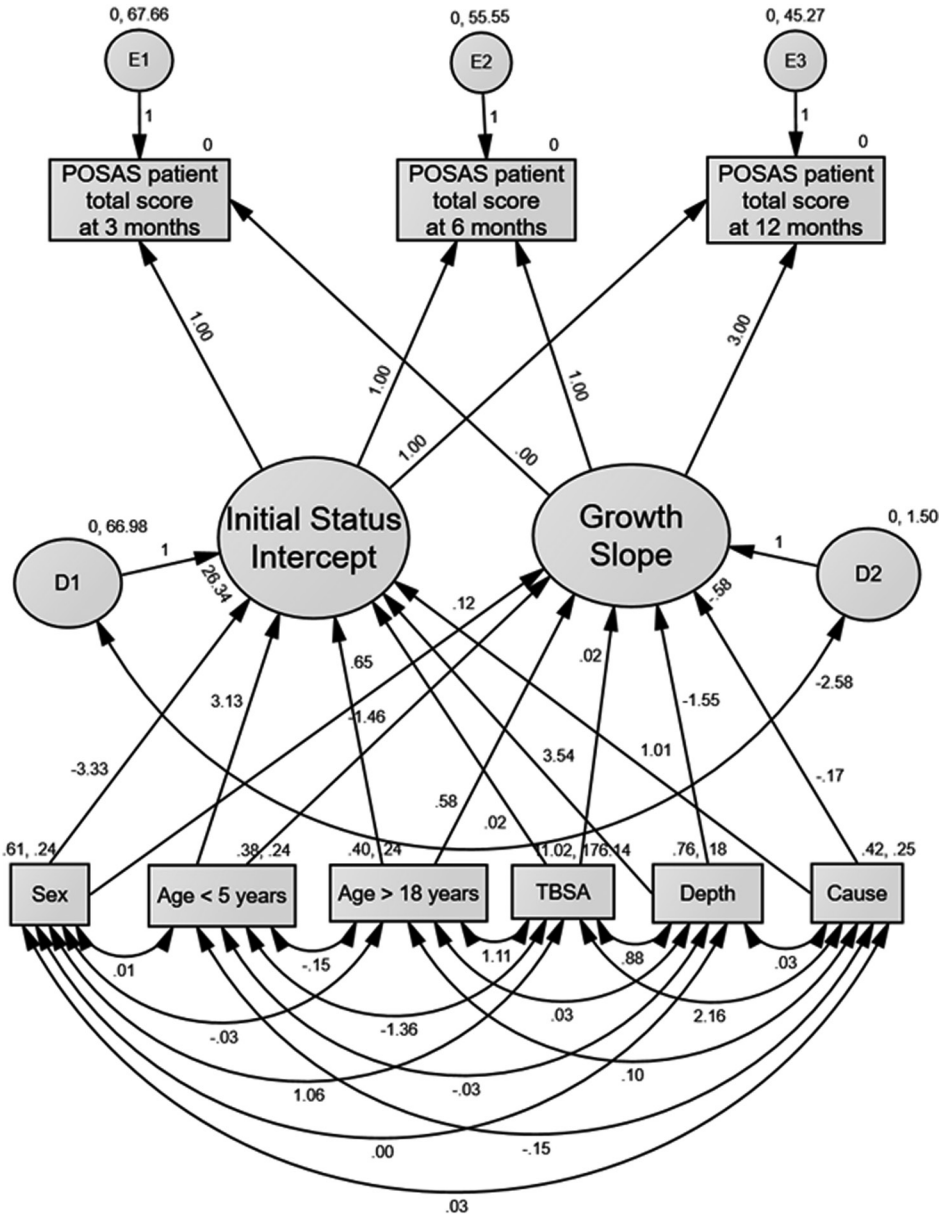

Appendix A. Hypothesized latent growth curve model of total POSAS patient scores measured at 3, 6 and 12 months post-burn with the estimates of several parameters. The time of the slope is coded 0, 1 and 3.

Appendix B. Fit indices for the different latent growth curve models.

Model	CMIN	df	*p*-value	CFI	RMSEA
Total score	3.58	1	0.059	0.98	0.07
Pain	0.11	1	0.744	1.00	0.00
Pruritus	2.19	1	0.139	0.99	0.05
Color	0.002	1	0.961	1.00	0.00
Pliability	0.000	1	1.00	1.00	0.00
Thickness	12.30	1	0.000	0.89	0.16
Relief	6.80	1	0.009	0.90	0.11
Total score + 6 predictors	6.75	7	0.455	1.00	0.00
Pain + 6 predictors	2.83	7	0.900	1.00	0.00
Pruritus + 6 predictors	5.29	7	0.624	1.00	0.00
Color + 6 predictors	8.38	7	0.301	0.99	0.02
Pliability + 6 predictors	8.74	7	0.272	0.99	0.02
Thickness + 6 predictors	12.90	7	0.075	0.99	0.04
Relief + 6 predictors	13.33	7	0.064	0.99	0.04

CMIN: minimum discrepancy, df: degrees of freedom, CFI: comparative fit index, RMSEA: root mean square error of approximation.

Appendix C. Covariances between predictor variables.

Predictor variables			Estimate	S.E.	C.R.	*p*
TBSA	-	Sex: male	1.060	0.302	3.512	**< 0.001**
TBSA	-	Depth: full thickness	0.876	0.265	3.307	**< 0.001**
TBSA	-	Age < 5 years	-1.361	0.303	4.494	**< 0.001**
TBSA	-	Age 5-18 years	0.249	0.253	0.983	0.326
TBSA	-	Age >18 years	0.249	0.253	0.983	0.326
TBSA	-	Cause: flame burns	2.161	0.327	6.613	**< 0.001**
Depth: full thickness	-	Sex: male	-0.004	0.010	-0.413	0.679
Depth: full thickness	-	Age < 5 years	-0.034	0.010	-3.553	**< 0.001**
Depth: full thickness	-	Age 5-18 years	< 0.001	0.008	0.060	0.952
Depth: full thickness	-	Age > 18 years	0.034	0.010	3.471	**< 0.001**
Depth: full thickness	-	Cause: flame burns	0.031	0.010	3.029	0.002
Cause: flame burns	-	Age < 5 years	-0.145	0.013	-11.019	**< 0.001**
Cause: flame burns	-	Age 5-18 years	0.044	0.010	4.449	**< 0.001**
Cause: flame burns	-	Age > 18 years	0.101	0.012	8.173	**< 0.001**
Sex: male	-	Age < 5 years	0.009	0.011	0.824	0.410
Sex: male	-	Age 5-18 years	0.018	0.009	1.945	0.052
Sex: male	-	Age > 18 years	-0.027	0.011	-2.449	**0.014**
Sex: male	-	Cause: flame burns	0.026	0.011	2.274	**0.023**
Age 5-18 years	-	Age < 5 years	-0.083	0.010	-8.334	**< 0.001**
Age 5-18 years	-	Age < 18 years	-0.088	0.010	-8.653	**< 0.001**
D1	-	D2	-2.585	4.372	-0.591	0.554

SE: standard error, CR: critical ratio, D1 - D2 is residual covariance.

Appendix D

Study model and statistical analyses

Absolute and comparative indices were calculated to test whether a latent growth curve model (LGM) fit in our model. As absolute fit indices, the minimum discrepancy (CMIN) and the comparative fit index (CFI) were presented. For the comparative fit index, the root mean square error of approximation (RMSEA) was calculated. The higher the probability associated with CMIN, the closer the fit was between the hypothesized model and the perfect fit. For CFI values, scores greater than 0.95 represented a well-fitting model. RMSEA values less than 0.05 were considered to be a good fit; those between 0.05 and 0.08 were considered a reasonable fit.(23, 39)

In AMOS, the estimates of the parameters, their standard errors and critical ratios (CR) were calculated. The CR refers to the estimates divided by their standard errors. Using a significance level of 0.05, any CR that exceeds 1.96 in magnitude is considered significant.

The path diagram is presented in Appendix A. Circles or ellipses represent unobserved latent variables and measurement errors or residual errors. Aspects of change (intercepts and slopes) are considered latent variables and are represented by arrows. The path from the intercept is constrained to the value 1, which reflects the fact that the intercept value remains constant across the three study time-points for each patient. The three fixed-slope variables 0, 1 and 3 represent the three time intervals of 3, 6 and 12 months elapsed since the burn. This fixed path was not estimated. Squares are measured variables: these include repeated measures of the dependent variable, POSAS patient scores and independent variables as predictors. Single-headed arrows indicate path coefficients (regression weights) and double-headed arrows indicate covariance between a pair of variables. E1, E2 and E3 are random measurement errors (residuals or disturbances). D1 and D2 are residuals that represent individual differences with respect to the intercept and slope parameters. The means of all five error terms were constrained to zero (marked by 0 in Appendix A); however, the error variances of these error terms were not constrained. The means and variances of the intercept and slope were not constrained equally across time in the model shown.