METHODS

Acoustic Assessment of Skin Grafts in Children with Burn Contractures

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The outcome of skin plasty is assessed quantitatively with the use of an acoustic skin analyzer, which allows one to measure the rate of the propagation of a surface acoustic wave in the skin. An objective criterion is proposed for evaluating the efficiency of grafting.

Key Words: *mechanical parameters of the skin; plasty*

Skin plasty (SP) is the principal method in the surgery of burn contractures in children. In 20-30% of cases SP is complicated by pronounced dystrophic changes of the graft sometimes leading to its necrosis. These complications usually result in scarring of the graft and recurrence of contractures.

Local oxygen therapy [3] and administration of tocopherol and ascorutine [1] have been proposed to increase the efficiency of grafting. Evaluation of the effectiveness of these approaches is based on visual assessment of dystrophic changes in the graft. For example, the following classification of the SP outcomes has been proposed [3]: good (the graft takes root without complications), satisfactory (necrosis of 15-20% of the graft), and poor (necrosis of more than 20% of the graft). Another classification [2] distinguishes four degrees of dystrophic changes in the graft: minor, medium, severe, and extremely severe. However, this classification also employs only visual criteria: the degree of edema, cyanosis, epithelial desquamation, etc. Thus, both classifications are based on subjective evaluation of biological parameters.

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Determination of rheological characteristics of the graft is a more objective approach. However, it cannot be used for assessing the outcome of SP in some areas of the body. This method is complex and provides little information regarding the degree of graft scarring, since the blood flow in the graft is lower than in intact tissues.

Analysis of recent publications showed that there are no simple methods for objective evaluation of the outcome of SP.

The aim of the present study is to improve the evaluation of the outcome of SP by characterizing the state of skin graft and the adjacent tissue using biomechanical parameters.

MATERIALS AND METHODS

The outcome of SP was evaluated using an acoustic tissue analyzer (ACA apparatus) [4,5] which allows one to characterize the state of a skin graft by measuring its mechanical parameters, such as the rate of the surface wave propagation in the skin (V) at different periods after surgery.

Fourteen 2-19-year-old patients with burn contractures were included in the study. Seven patients had contractures of the fingers, 2 patients had contractures of the shoulder, 2 patients had neck contractures, 2 patients had elbow contractures, and 1 patient had ankle contracture. The operation consisted in the excision of the scar followed by replacement with a full-thickness graft. The graft was taken from the abdominal wall (8 patients), buttocks (3), and the internal forearm surface (3).

Biomechanical parameters were assessed according to the following scheme. First, the donor area was chosen, and a control line was drawn as a series of points at 0.5-1 cm intervals. Before the surgery, the rate of acoustic waves propagating in two perpendicular directions (V_x and V_y) was measured three times in these points (the X and Y directions were perpendicular and parallel to the body axis, respectively). The coefficient of skin anisotropy in the donor area was calculated as the V_y/V_x ratio. The coefficient was positive at $V_y>V_x$ and negative at $V_y<V_x$.

After the scar was excised and the contracture was removed, graft was taken from the donor area, stripped of subcutaneous fat, and stitched to the wound surface by interrupted suture so that its X and Y axes remained parallel and perpendicular to the body axis, respectively. An aseptic dressing was then applied. The wound in the donor area was closed by edge mobilization.

The first acoustic scanning was made on day 3 during the first dressing change. The measurements were performed in intact skin and in the marked points on the graft in two perpendicular directions. Subsequent measurements were performed on days 10 and 15 postoperation. Sometimes they were repeated after 10 and 18 months.

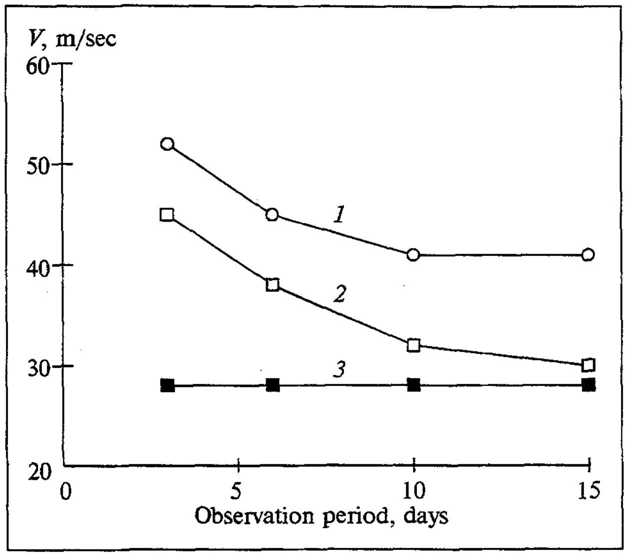

Fig. 1. Rate of the propagation of a surface acoustic wave (V) in skin graft in poor (*1*) and successful (*2*) grafting and in intact skin (*3*) as a function of time.

RESULTS

The patients were divided into two groups: group 1 consisted of 9 patients with satisfactory outcome and group 2 included 5 patients with poor outcome.

TABLE 1. Rate of Acoustic Wave Propagation in Donor Site (V_0), Graft (V_g), and Their Difference (ΔV), m/sec

Patient No.	Graft	Donor site							
		days 5-7		day 10		day 15		day 60	
	V_0	V_g	ΔV	V_g	ΔV	V_g	ΔV	V_g	ΔV
Successful graft take									
1	28	38	10	32	4	30	2		
2	22	40	18	28	6	26	4		
3	32	40	8	38	6	35	3		
4	32	40	8	32	0	34	2		
5	27	40	13	36	9	33	6		
6	26	40	14	36	10	30	4		
7	30	36	6	30	0	30	0		
8	31	40	9	36	5	30	1		
9	24	35	11	30	6	24	0		
Poor graft take									
10	28	40	12	39	11	38	10	37	9
11	27	45	18	40	13	40	13	39	12
12	29	39	10	39	10	38	9	42	13
13	29	40	11	42	13	44	15	44	15
14	29	44	15	39	10	38	9	37	8

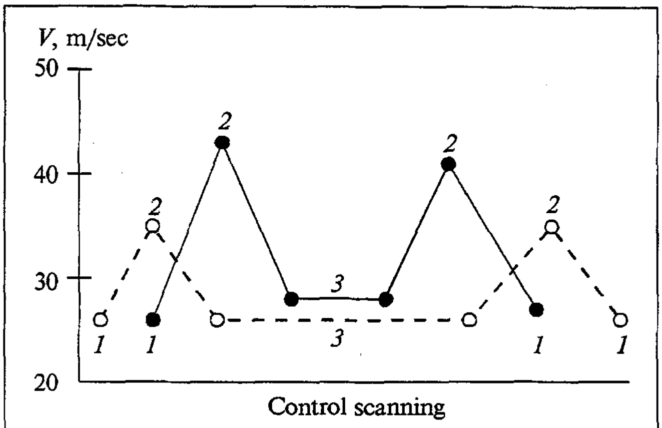

Fig. 2. Acoustic scanning of the skin in the area of plasty 10 (solid line) and 18 months (broken line) after the surgery. Areas of the operation field: *1*) intact skin; *2*) scar; *3*) graft.

The profile of acoustic scanning in the *X* direction is given in Table 1.

The use of ACA apparatus allows one to study the dynamics of the establishment of the graft. To this end, we measured the wave rate in the control points during dressing changes until a compressing plaster cast was applied. Figure 1 illustrates the dynamics of the surface acoustic wave rate in different outcomes of grafting.

On the basis of our findings we propose the following quantitative prognostic criterion for the efficiency of skin grafting: if the rate of the surface acoustic wave propagation in the graft differs from the initial rate in the donor area by no more than 15%, the outcome is satisfactory; greater differences are indicative of a poor prognosis.

The results of scanning of the operation field (intact skin, suture scar, and graft) 10 and 18 months after surgery are shown in Fig 2. In successful grafting, there is no considerable difference between the mechanical parameters of the graft and adjacent intact skin. However, the rate of the wave propagation is higher in the scar. This parameter decreases with time both in the scar and graft and becomes comparable to that in the surrounding intact skin.

The comparison of perpendicular rates made it possible to evaluate the mechanical anisotropy in SP. In our study, grafts were taken from the sites with a low coefficient of anisotropy: the abdominal wall and buttocks (*K* varied from 0.9 to 1.16). On day 15 postoperation, *K* varied from 0.8 to 1.1, being positive or negative. The sign of the coefficient was preserved at remote periods after surgery.

Thus, our findings may be useful for objective evaluation of the outcome of skin plasty. The biomechanical parameter of the skin graft (the rate of the propagation of acoustic waves) may be used as a prognostic criterion. The dynamics of postoperative changes in biomechanical parameters may be helpful for the choice of the treatment strategy, which is of crucial importance for successful SP.

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