

## The comparison of two methods of treatment evaluating complications and deficiency of functions of hands after deep partial skin thickness hand burns

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**Key words:** hand burns; hand injuries; skin grafting.

**Summary.** Hands actively participate in daily activities of a human; therefore, hands are the most vulnerable parts of the human body. People injure hands so often because namely hands are in the closest position to the dangerous equipment. According to the data of various authors, the injuries of hands and fingers make even 30–75% of all industrial traumas, and burns of hands account for about 6% of all traumas of hands.

The aim of the study was to compare the effectiveness of active surgical treatment method with conservative treatment method, applied for the treatment of deep dermal partial skin thickness burns of the hands, wrists, and forearms of distal third.

**Materials and methods.** A total of 49 patients with burned hands participated in the perspective study of random sample (totally 79 hands). All these patients were treated in the Department of Plastic and Reconstructive Surgery, Hospital of Kaunas University of Medicine, during the period of 2001–2005. The patients were assessed after 3, 6, and 12 months.

**Results.** Applying conservative method of treatment of deep partial skin thickness burns, the frequency of infectious complications was increased. In order to evaluate the state of scar, we applied the scale of Vancouver and analyzed the pigmentation of a scar, its height, flexibility, and color. After statistical analysis had been performed, we determined that more changes of skin were seen in the group, which received active surgical treatment ( $P < 0.05$ ).

**Conclusions.** Statistically significantly fewer complications were in the group of active surgical treatment in the early (fewer infectious complications, smaller area of unnaturalized autograft) and in the late (scars were less rough, with less changes of pigmentation) postoperative periods.

### Introduction

Hands actively participate in daily activities of a human, and therefore, hands are the most vulnerable parts of the human body. People injure hands so often because hands are always close to dangerous equipment (1). Hands often suffer while trying to protect other parts of body from flame and other injuring factors. According to the data received from various authors, the injuries of hands and fingers make even 30–75% of all industrial traumas (2–4), and burns of hands account for about 6% of all traumas of hands (5).

To set the exact number of patients with hand burns is very difficult because neither European countries nor the United States have a register of patients categorized according to the burned area. The number of patients with hand burns could be assessed only ac-

ording to the number of patients who were hospitalized. This number should precisely reflect a real situation because the majority of countries work in line with recommendations of the Association of American Surgeons of Hands, and these patients are treated at hospitals (6, 7). The number of patients with burned hands is different in various articles. The number of all patients with burns, who were treated at hospitals, varies from 10% to 70% (8–12). In 50% of all cases, people burn both hands (13). According to the data in literature, reconstructive surgeries are needed for 1.9% of hospitalized patients, during which microvascular patches are transplanted (14).

The treatment of burns of hands, wrists, and forearms of distal dorsal surface is very problematical (8, 15). This area of body contains a lot of minor structures, which are located under a thin layer of

hypoderm. Therefore, even comparatively inconsiderable changes of skin and other functionally important structures, caused by traumas, may influence the functions of hands.

A doctor who treats burns questions when to operate patients who have sustained deep burns of hands of partial skin thickness (7). Some authors think that the most reasonable is to operate as soon as the depth of burn is identified (2, 6, 16–21). Usually the surgeries are performed on the second–third day after the burn, of course, if general health status of a patient allows that (22, 23). According to the data of these authors, the best function outcome can be achieved if the surgery is performed within the first two weeks after the burn (6, 7, 14, 16, 24, 25). Repeated surgeries are the least needed to these patients. They recover and are discharged from a hospital much quicker, which is very important from the economic point of view (7, 9, 17, 24, 26, 27). Other authors suggest waiting for self-epithelization of wounds for 2–3 weeks and only then covering unhealed wounds with dermo-grafts. According to these authors, the same functional results as during early necrectomy and plastic surgery can be achieved by actively applying physiotherapeutic cure and scar hypertrophy suppressive means to avoid complications related to active surgical intervention (8, 26, 28).

The aim of the study was to compare the effectiveness of active surgical tactics method with a conservative method, applied for the treatment of deep partial skin thickness burns of hands, wrists, and forearms of distal third.

The tasks of the study were to compare the deficiency of functions, state of scars, cosmetic view, and the number of complications within the groups of different treatment.

### Materials and methods

A total of 49 patients with burned hands participated in the perspective study of random samples (totally 79 hands). All these patients were treated in the Department of Plastic and Reconstructive Surgery, Hospital of Kaunas University of Medicine, during the period of 2001–2005. The patients were assessed at 3, 6, and 12 months postinjury. The study was approved by the independent Ethics Committee of Kaunas University of Medicine.

Inclusion criteria of patients to the study were as follows:

1. Patients with burned hands and/or wrists;
2. Cause of burns: flame, hot water, water steam, contact with hot things, chemical substances,

electric trauma;

3. Deep partial skin thickness burns of the hands;
4. Informed consent of a patient to participate in the study;
5. The total burned area is <40% of the body surface.

The patients were treated following the local treatment protocol of burns. The depth of burns was evaluated 24–48 hours after a burn. If the burn 2B° was clinically diagnosed, 1×3-mm pieces of skin were cut off by disposable scalpels in order to perform the histological analysis. Skin pieces were fixed in 10% formalin. Histological preparations were embedded into paraffin and later were stained with hematoxylin-eosin. The layer of epidermis (if it had remained) and the thickness of coagulation of tissue were evaluated while analyzing preparations with a microscope. The damaged layers of skin were identified. Having the results of histological analysis, the match between the depth of clinical burn and histological view was evaluated.

The patients were divided into two groups randomly. Active surgical treatment was applied to patients in the group A. Wounds of the burned hands were bandaged with ointment of 1% silver sulfadiazine, spreading the layer of 1–2 mm of ointment before the surgery. Each finger was bandaged separately with gauze bandage. Necrectomy and autodermoplastics of partial skin thickness were performed within 7 days after the burn. The patients in the group B every second day were bandaged with ointment of 1% silver sulfadiazine. The wounds had been bandaged until their full epithelization. Autodermoplastics was performed if islets of epithelization did not emerge within 14 days after the separation of unviable tissues. Hands of both groups were immobilized in their functional position, and passive movements of the wrists and fingers were performed.

**The analysis of early complications.** The frequency of infection was analyzed while examining the early complications. After hospitalization of patients, the samples of wounds were obtained if an infection was suspected. Microorganisms isolated from the wounds and their sensitivity to antibiotics were evaluated.

**The analysis of late complications. The evaluation of a scar according to the scale of Vancouver.** In order to evaluate the results of treatment 12 months after the surgery, the formed scar was evaluated (its pigmentation, color, bump, and elasticity). The pigmentation of the scar, its height, and color were evaluated on a scale from 0 to 3. Elasticity was evaluated on a scale from 0 to 5 according to the scale of Vancouver

(29). The scars of the burned hands that changed the most were evaluated. The points, which had been measured while analyzing the scar, were summed up. The states of scars were compared during the late postoperative period in the groups of patients to whom different methods of treatment had been applied. The cosmetic appearance of a hand was evaluated subjectively by a patient himself/herself.

**The examination of disorder of sensation.** Examining disorders of sensations, the discrimination of two points "Hands on" (Samsons Preston, Ability One, USA) was evaluated using needles, fixed by standard distances. At the beginning of the examination, the distance between needles was 2 mm, later it was increased up to 15 mm by 1 mm till the patient started feeling the touch of both needles (not only one). This examination was repeated for three times, and the best result was recorded.

**The evaluation of deficiency of functions.** The measured amplitudes of joint movements (using goniometer) were converted into percents of deficiency of functions of hands using Hunter's and Co tables (30).

The analysis of the data was performed using a program software package Statistica 5.0 (StatSoft Inc., USA). The study presents the quantitative averages of variables and standard deviations. We have checked the hypothesis of normal distribution of variables using Shapiro-Wilks test. As the normal distribution of variables was identified, the differences of averages of groups were compared using Student *t* test among independent samples, and the abnormal distribution of variables was identified using Mann Whitney *U* test. Comparing the changes of hand functions of the same patients after 3, 6, and 12 months, the paired (*t*) criteria of Student were applied and, in cases of abnormal samples, Wilcoxon criteria was applied. The hypothesis of the equality of quantitative distribution of variables among groups was checked using non-parametric criteria ( $\chi^2$ ) of chi-square. Moreover, if the number of frequencies was small, Fisher exact test was applied. The influence of other qualitative variables on a quantitative variable was evaluated by the method of disperse analysis. We considered *P* value of <0.05 as statistically significant.

## Results

A total of 49 patients with 79 burned hands participated in the perspective study of random samples. All these patients were treated at the Department of Plastic Surgery and Burns, Hospital of Kaunas University of Medicine, from 2001 to 2005. All patients

were assessed after 3 and 6 months, while after 12 months, 2 patients from the group B and 2 patients from the group A did not come.

Eighteen men (75%) with a total number of 31 burned hands (77.5%) and 6 women (25%) with a total number of 9 burned hands (22.5%) were assigned to the group that received active surgical treatment (group A). Seventeen men (68%) with a total number of 27 burned hands (69.2%) and 8 women (32%) with a total number of 12 burned hands (30.8%) were assigned to the group that received conservative treatment (group B). In total, there were 35 men (71.43%) and 14 women (28.57%) enrolled into the study. The burns of both hands were diagnosed to 16 (66.6%) patients in the group A and to 14 (56%) patients in the group B. The percentage of patients, to whom the burns of both hands had been diagnosed, was 61.2%. Four patients (16.7%) in the group A and four patients in the group B (16%) sustained burns of the left hand. Four patients (16.7%) in the group A and seven patients (28%) in the group B sustained burns of the right hand.

The dominant hand of all patients was right. In the group of early necrectomy and plastic surgery, the functions of 20 (50%) nondominant and 20 (50%) dominant hands were analyzed. In the group of delayed necrectomy and plastic surgery, the functions of 18 (46.2%) nondominant and 21 (53.8%) dominant hands were analyzed. We compared both groups according to the age. It was observed that the patients of the group B were older than the patients of the group A ( $46.68 \pm 2.77$  vs.  $39.75 \pm 2.8$  years); however, the difference was not statistically significant ( $P=0.085$ ).

We did not find any statistically significant difference while comparing groups according to the burned areas of the joints.

Comparing groups according to the total area of burned body surface, we did not find any statistically significant difference ( $11.56 \pm 2.57\%$  in the group A vs.  $15.32 \pm 2.28\%$  in the group B;  $P=0.28$ ). We also did not find any difference while comparing the groups according to the burned area of the hands ( $62.8 \pm 5.16\%$  in the group A and  $71.42 \pm 4.93\%$  in the group B;  $P=0.23$ ).

The main cause of injury in both groups was burns caused by flame (21 (87.5%) cases in the group A and 19 (76%) cases in the group B).

**The evaluation of early complications.** While evaluating the results of the treatment, we analyzed the frequency of infectious complications. We found that pathogenic microorganisms were isolated from

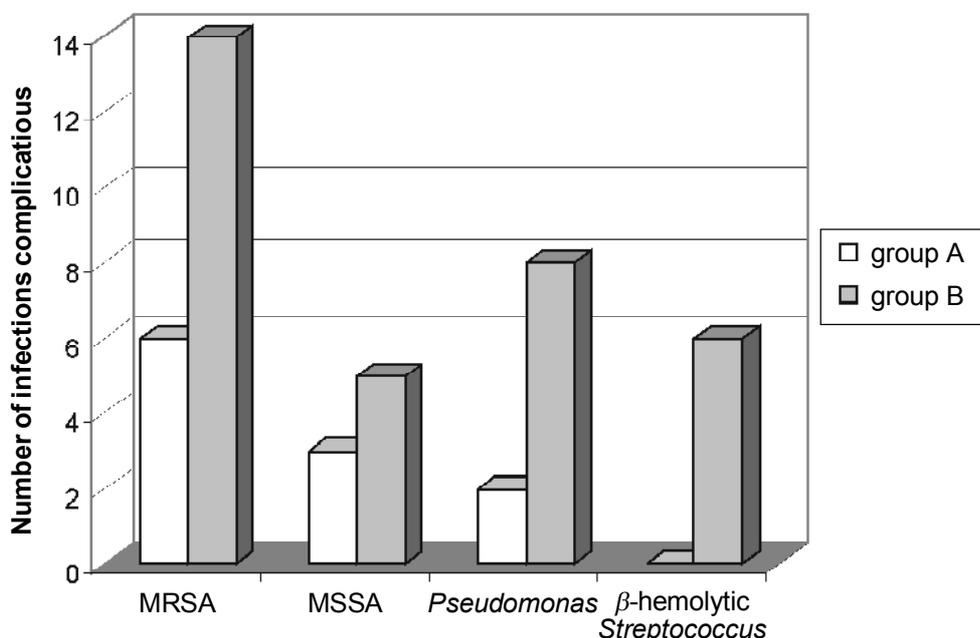
11 (27.5%) wound specimens of burned hands in the group A. There were 6 (15.0%) cases of hospital methicillin-resistant *S. aureus* (MRSA), 3 (7.5%) cases of methicillin-sensitive *S. aureus* (MSSA), and 2 (5.0%) cases of *Pseudomonas aeruginosa*. Respectively, in the group B, pathogenic microorganisms were found in 33 (84.6%) wound specimens of the burned hands. There were 14 (35.9%) cases of MRSA, 5 (12.8%) cases of MSSA, 8 (20.5%) cases of *Pseudomonas aeruginosa*, and 6 (15.4%) cases of  $\beta$ -hemolytic streptococcus.

The area of autograft that had not naturalized was evaluated during bandaging, 7 days after the surgery. The results were grouped into four groups. During the study, it was found that there were no cases when

whole autograft would not naturalize (Fig. 1).

While comparing the naturalization of grafts within groups A and B, we noticed that there were statistically significantly more cases (64.1%) in the group B when the percentage of unnaturalized graft was higher than 25%, while in group A there were only 20% of such cases ( $P=0.001$ ).

**The evaluation of scars according to the scale of Vancouver.** Evaluating the late complications, we analyzed the state of formed scars according to the scale of Vancouver (Table 1). There was a statistically significant difference comparing the mean scores between the groups ( $3.65\pm 2.93$  in the group A vs.  $6.77\pm 2.96$  in the group B;  $P<0.001$ ). We clinically analyzed the state of scars of the hands 12 months



**Fig. 1.** The comparison of number of infectious complications between groups A and B

MRSA – methicillin-resistant *Staphylococcus aureus*,  
MSSA – methicillin-sensitive *Staphylococcus aureus*.

**Table 1.** The evaluation of a scar according to the scale of Vancouver

Score	Pigmentation of scar		Height of scar		Flexibility of scar		Color of scar	
	group A	group B	group A	group B	group A	group B	group A	group B
0	16	3	15	4	4	0	23	11
1	12	4	17	21	22	13	11	14
2	5	14	6	8	8	13	2	7
3	5	16	0	4	2	7	2	5
4	0	0	0	0	2	4	0	0
Totally	38	37	38	37	38	37	38	37
	$P<0.01$		$P<0.01$		$P=0.01$		$P=0.02$	

after the burn. During the study, we noticed that the color of scars, which formed in the dorsal side of the hands of group A patients, pigmentation, the height of scars, and elasticity were more like those of undamaged skin. Scars that formed in the B group were thicker, less elastic, and with greater changes of pigmentation.

**The cosmetic evaluation of hands.** During the study, patients could subjectively evaluate the cosmetic appearance of their hands. The evaluation was performed on a scale of 1 to 4: 1 score, the cosmetic appearance is close to normal; 4 scores, unsatisfactory cosmetic appearance. Twelve (30.0%) patients of group A evaluated the cosmetic appearance of their hands as very good, 22 (55.0%) patients evaluated as good, 4 (10.0%) patients as satisfactory, and 2 (5.0%) patients as unsatisfactory. Respectively, the answers in the group B were as follows: 3 (7.7%) patients evaluated as very good, 14 (35.9%) patients as good, 16 (41.0%) patients as satisfactory, and 16 (41.0%) patients as unsatisfactory. The mean score in the group A was  $1.9 \pm 0.78$  and in the group B –  $2.64 \pm 0.84$  ( $P < 0.001$ ).

**The analysis of discrimination of two points of fingers.** While analyzing the functions of hands, we evaluated the disorders of sensations. During the study, we evaluated statistical discrimination of two points on the dorsal side of the fingers. The results are indicated in Fig. 2. During the study, we determined that the discrimination of two points of the fingers was better in the group A (except the sensa-

tions of V finger after 6 and 12 months). In the group A, partial numbness of III, IV, and V fingers was diagnosed to one patient. In the group B, partial numbness of IV finger was diagnosed to one patient. However, according to these data and comparison of averages of discrimination of two fingers, there was no statistically significant difference ( $P > 0.05$ ).

**The evaluation of deficiency of functions.** While evaluating the deficiency of functions, we measured the deficiency of each joint in degrees. Later these data were converted into the percentage of deficiency of a joint, and the deficiency of function, which originated because of burn of wrist or hand, of each finger, hand, and arm was calculated. We measured the deficiency of functions of the hands and arms after 3, 6, and 12 months. After the comparison of deficiency of functions of the hands between the groups A and B, we determined that the deficiency in the group A was statistically significantly lower during all studied periods (Table 2).

While analyzing the deficiency of arms, we evaluated the influence of burns of the hands and wrists on functions of arms. We found that a statistically significantly lower deficiency of function was in the group A during all studied periods (Table 3).

After the comparison of deficiency of functions of the arms after 3, 6, and 12 months, we found that the deficiency was lower as time passed (Fig. 3). After 12 months, the deficiency of functions of the hands and arms was statistically significantly lower than 3 or 6 months after burn ( $P < 0.05$ ).

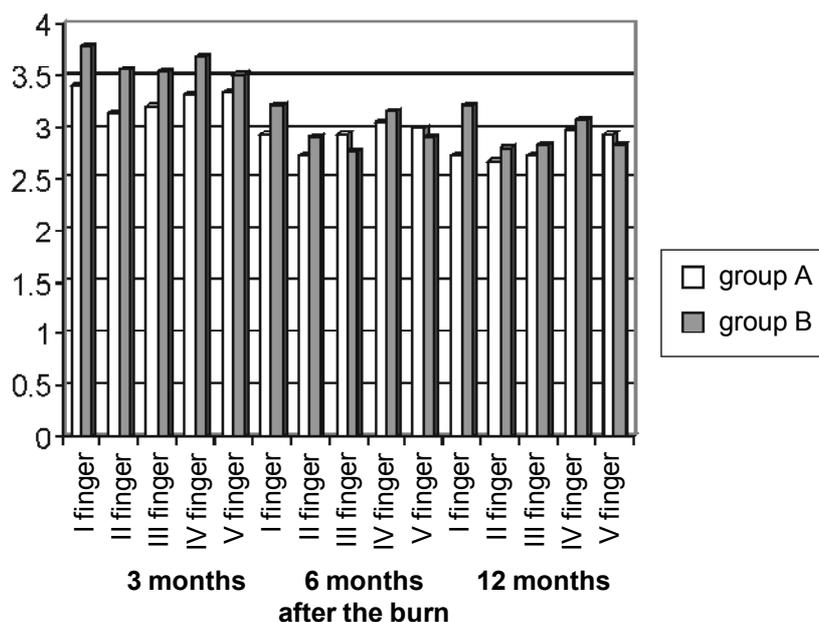


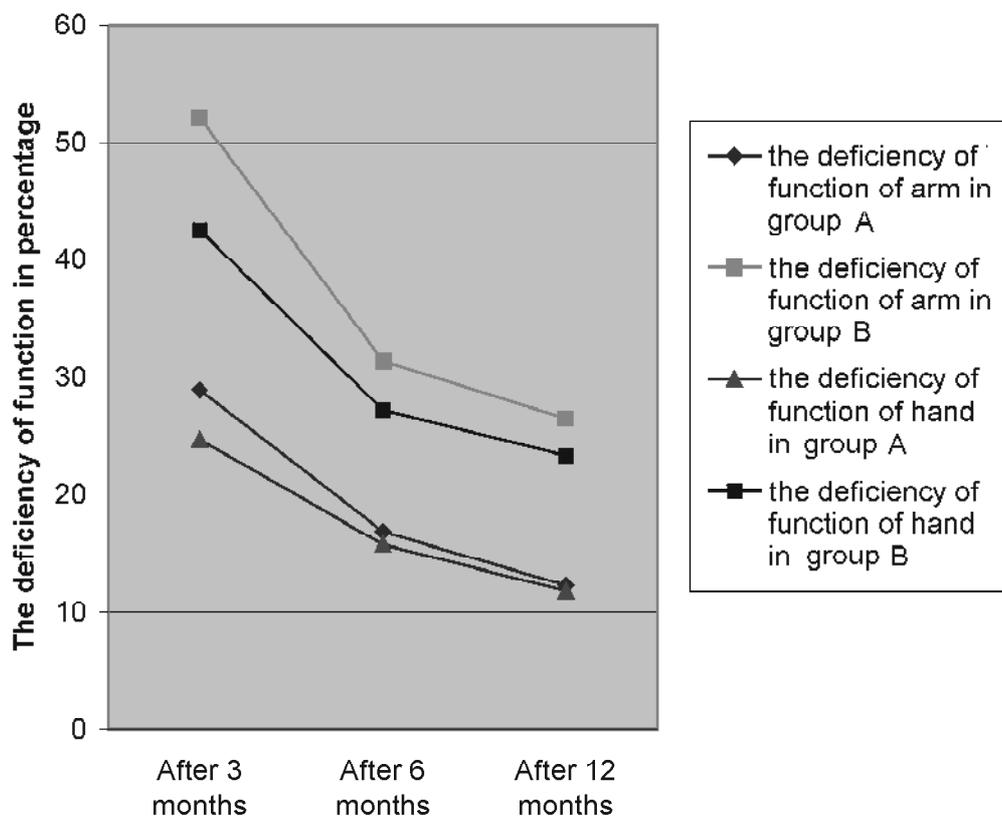
Fig. 2. The analysis of discrimination of two points of fingers

**Table 2. The comparison of deficiency of functions of hands between groups of AST and ST after 3, 6, and 12 months**

Level of deficiency at different time points		Group A	Group B	P value
The deficiency of function of hands after 3 months	Active	24.73±2.19	42.56±2.08	<0.001
	Passive	21.47±2.66	45.26±2.60	<0.001
The deficiency of function of hands after 6 months	Active	15.8±1.65	27.26±1.96	<0.001
	Passive	10.45±1.50	24.9±2.37	<0.001
The deficiency of function of hands after 12 months	Active	11.83±1.41	23.36±1.98	<0.001
	Passive	7.2±1.33	17.3±1.85	<0.001

**Table 3. The comparison of deficiency of functions of arms between groups after 3, 6, and 12 months**

Level of deficiency at different time points		Group A	Group B	P value
The deficiency of function of arms after 3 months	Active	28.98±2.57	52.15±2.51	<0.001
	Passive	19.45±2.39	40.79±2.35	<0.001
The deficiency of function of arms after 6 months	Active	16.9±1.67	31.44±2.39	<0.001
	Passive	9.5±1.34	22.41±2.12	<0.001
The deficiency of function of arms after 12 months	Active	12.33±1.44	26.51±2.29	<0.001
	Passive	7.1±1.23	18.46±2.07	<0.001

**Fig. 3. The change of deficiency of function of the hands and arms after 3, 6, and 12 months**

Despite the fact that functions of hands were improving over the time, quite a big deficiency of arms and hands after 12 months still remained. In the group B, the deficiency of functions of the hands reached 23% and the deficiency of functions of the arms reached 26.5%. Consequently,  $1/4-1/5$  of previous functions did not recover, while in the group A, deficiency of the hands and arms reached 12%.

### Discussion

According to the data in literature, men suffer from burns twice as much as (71%) women (31). In our sample analyzed, there were 71.43% of men and 28.57% of women.

We have also compared the average age, indicated in the literature, with the average age of our studied sample. According to the data in literature, the mean age of patients who sustained burns was 40–45 years (31). In our analyzed sample, the mean age in the group A was 39.75 years and in the group B – 46.68 years. These numbers conform to the average age of people with burns, indicated in the scientific articles.

Evaluating the complications that emerged at the early postoperative period, we analyzed the frequency of infectious complications and unnaturalized area of autografts.

Applying conservative method in the treatment of deep partial skin thickness burns, the frequency of infectious complications increases (8, 13, 27). We analyzed the most frequent pathogenic microorganisms in wound specimens. MRSA was isolated from 6 patients of group A and 14 patients of group B. The difference in the number of MSSA between groups was rather small: 3 in the group A and 5 in the group B. *Pseudomonas aeruginosa* was found in two samples of group A and in 8 samples of group B. Moreover, there were six cases of  $\beta$ -hemolytic streptococcus in the group B. However, no cases of this microorganism were found in the group A. We did not find statistically significant difference analyzing the occurrence of methicillin-sensitive *S. aureus* in the wounds of burned hands. Therefore, the results of our study proved the hypothesis that the risk of infectious complications is much higher applying the tactics of conservative treatment.

The rejection of autograft after the surgery may occur due to insufficient removal of unviable tissues, due to accumulation of blood under the graft, and due to infection (15, 25, 32, 33). During our study, unviable tissues were not found at the place of autograft; therefore, we might claim that unviable tissues were fully removed in all cases. Besides, there were no

cases of rejection of grafts due to accumulated blood under them, because we always perforated the autografts during operations. Therefore, the only cause of the rejection of autografts could be infection. In the group A, less than half of the autografts did not naturalize on 8 hands and in the group B on 17 hands. Moreover, in the group B, the unnaturalization of autograft of 51–75% was identified on eight hands. Comparing the groups according to the unnaturalization of autografts, we established a statistically significant difference. According to our data, the rejection of graft of various degrees in the group A was identified in 8 cases (20%), while in the group B, in 25 cases (64%). It is confirmed by the findings of the study, carried out by Fadaak and coauthors in 2001.

In the literature, which analyzes the treatment of burned hands, one may find several articles about the treatment of postburn syndactyly. The literature indicates that webbing forms even in up to 14% of patients with bunt hands (46); other authors claim that during the period of 7 years, they performed surgeries in 190 patients who had syndactyly after the burn (34); however, these authors did not indicate the degree of syndactyly and the percentage of web-fingered patients. In our groups studied, the number of the web-fingered exceeded the number indicated in the literature. Syndactylies were diagnosed to 14 patients (35%) in the group A and to 15 patients in the group B (38%). In both groups, 1° webbing prevailed. Only to one patient of group A and to one patient of group B, 3° syndactyly was diagnosed. In both cases, the healing was prolonged due to infection. Evaluating the groups according to the frequency of formation of syndactyly, we did not find statistically significant difference.

In the literature we reviewed, in the studies on functions of the hands, the cosmetic appearance of the hands was not analyzed (25, 35), or the authors were confined only with subjective evaluation by pointing out that the view was either good or bad, or the skin looked like normal or unchanged (26). Other authors evaluated both cosmetic appearance and the state of scars but their studies compared several methods of autodermoplastics (perforating or not perforating the autograft) (36) or scars were evaluated after the use of skin substitutes (37, 38).

To evaluate and objectively define the state of scar, we applied the scale of Vancouver and analyzed the pigmentation of a scar, its height, flexibility, and color. All these criteria were scored. After statistical analysis had been performed, we identified that skin had changed statistically significantly less in the group A ( $P < 0.05$ ).

Moreover, the patients evaluated the cosmetic appearance of hands by themselves. Statistically significantly better results were indicated by patients of group A ( $P < 0.05$ ).

While evaluating the general functions of hands and arms, we analyzed the deficiency of functions of hands and arms. Unfortunately, we failed to find any studies that analyzed the functions of hands of hand burned patients according to the same methodology. Some of the authors, analyzing the function of hands, rated the general amplitude of movements of the fingers (24). That method is objective for the evaluation of functions of the hands, but the disorder of the wrist cannot be evaluated by applying that method. According to our methodology, we evaluated objectively not only the deficiency of functions of hands

but also the deficiency of wrist functions, caused by hand traumas.

Even though the results in the group A were better, we found that functions of the hands were not fully restored. This fact shows that none of these methods of treatment is ideal. Therefore, other methods of treatment, which could help to restore better functions and viability of hands, should be found.

### Conclusions

Statistically significantly fewer complications were in the group of active surgical treatment in the early (fewer infectious complications, smaller area of unnaturalized autograft) and in the late (scars were less rough, with fewer changes of pigmentation) post-operative periods.

## Dviejų gydymo metodų palyginimas vertinant komplikacijas ir funkcijos nepakankamumą po gilaus dalies odos storio plaštakų nudegimo

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**Raktažodžiai:** plaštakos nudegimai, plaštakos pažeidimas, odos persodinimas.

**Santrauka.** Rankos aktyviai dalyvauja kasdienėje žmogaus veikloje, todėl yra labiausiai pažeidžiamos žmogaus kūno dalys. Jos dažnai ir sužalojamos. Neretai plaštakos nukenčia bandant apsaugoti kitas kūno dalis nuo liepsnos ar kitų žalojančių veiksnių. Įvairių autorių duomenimis, plaštakų ir pirštų sužalojimams sudaro net 30–75 proc. gamybinių traumų, o plaštakų nudegimai sudaro apie 6 proc. visų plaštakų traumų.

**Tyrimo tikslas.** Palyginti aktyvios chirurginės taktikos metodo veiksmingumą su konservatyviuoju metodu gydant plaštakų, riešo ir dilbio distalinio trečdaliao gilius dalies odos storio nudegimus.

**Tyrimo medžiaga ir metodai.** Perspektyviajame atsitiktinių imčių tyrime dalyvavo 49 pacientai, nudegę plaštakas (iš viso 79 plaštakos). Šie pacientai gydyti Kauno medicinos universiteto Plastinės chirurgijos ir nudegimų skyriuje 2000–2004 m. Kontrolinis tyrimas atliktas po 3, 6 ir 12 mėnesių.

**Rezultatai.** Naudojant konservatyvų gilaus dalies odos storio nudegimo gydymo metodą, išaugo infekcinių komplikacijų skaičius. Vertindami randų būklę, naudojome Vankuverio skalę, pagal kurią vertinome rando pigmentaciją, dydį, paslankumą bei spalvą. Atlikę statistinę analizę, nustatėme, kad statistiškai reikšmingai ( $p < 0,05$ ) didesni odos pokyčiai buvo A grupėje.

**Išvada.** Aktyvios chirurginės taktikos grupėje buvo statistiškai reikšmingai mažiau komplikacijų ankstyvuju (mažiau infekcinių komplikacijų, mažesnis neprigijusio autodermotransplantato plotas) ir vėlyvuju (ne tokie grubūs randai su mažesniais pigmentacijos pokyčiais) pooperaciniu laikotarpiu.

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