Analysis of burned hand function  
(early versus delayed treatment)

Kęstutis Maslauskas, Rytis Rimdeika, Jolita Rapolienė¹, Tadas Ramanauskas¹  
Department of Surgery, Kaunas University of Medicine, ¹Kaunas University of Medicine

**Key words:** hand injuries, hand burns, hand burns treatment, hand function.

**Summary.** The aim of this study was analyze the results of hand function in adult patients with deep partial thickness hand burns. All patients were treated in Kaunas University of Medicine Hospital in Lithuania during the period 2001–2004.

Material and methods. A total of 79 cases were reviewed prospectively. We divided the studied patients into two groups by the envelope method (A group of early and B of delayed necrectomy and plasty). Two treatment methods – early and delayed surgery – have been analyzed. We present results of analysis of hand function in the periods of 3 and 12 months after the burn injuries of the hands.

Results. During the study we ascertain that the deficiency of hand function in group A 3 and 12 months after the injury was lower than that in group B. The deficiencies of hand and arm functions decreased over time. After a period of 12 months the deficiency of hand and arm functions in group A reached 12%, while in group B the deficiencies of hand and arm function reached 23% and 26.5%, respectively.

The study revealed that the deficiency of hand function because of wrist and hand burn depended on the age of patient, the area of hand burn, time period from the injury to the arriving to a hospital and time to the operation.

The strength of digit pinch and hand grasp was larger in group A. Twelve months after the burn the strength measured in A and B groups was larger than that measured 3 months after the burn. The strength of hand grasp in group A in male patients regenerated up to 76%, in female – 61% of norm. In group B the strength of hand grasp in male patients regenerated up to 60.8% and in female – 39.36%.

Conclusions. During the perspective analysis it was determined that after periods of 3 and 12 months after the injury the strength pinch and grip was statistically significantly larger in group A. The deficiency of hand function, which indicates the general hand function, was statistically significantly lower in group A.

**Introduction**

Hands participate in everyday humans activities and they are the most vulnerable parts of a human body. They are often injured because of being closest to dangerous facilities (1). Hands are often injured trying to cover other parts of a body from the fire or other destructive factors. As different authors stated the hand and digit injuries comprise 30–75% of industrial injuries (2–4). Hand burns comprise 6% of all hand injuries. Human loses up to 54% of function when he loses his hand function (5).

Every year about 500 patients who sustained burns are treated in specialized centers of Lithuania. Almost half of them are diagnosed with one or both hands burns while 15–20% of patients sustained deep hand burns. Most often these patients get burned contacting with fire (50%), less common burns are due to hot water (31%); 2–6% of patients sustained electricity injuries (6) and the rest of the patients have been burned with chemical materials or during the contact with hot objects. More than two-thirds (71%) of all patients sustained burn injuries are males. The average age of these patients is 40–45 years (7). The literature suggests that 1.9% of the patients who sustained hand burns need reconstructive operation – microvascular flap transplantation (8).

Because of such large number of hand burns the study of perspective accidental data comparing two methods of treatment in the Division of Plastic and Reconstructive Surgery of Kaunas University of Medi-
cine Hospital was carried out. Study included patients with deep partial-thickness hand burns who agreed to participate in evaluation.

**Materials and methods**

The study of perspective accidental data included patients who sustained deep partial-thickness hand burns. Study involved patients who sustained burns of the dorsal part of hand and (or) wrist during the contact with a fire, hot water, water steam, hot objects, chemical materials or during the electrical injury; hand burn of 2B°; the burned area – less than 40% of total body surface area; patients’ agreement to participate in the investigation. Exclusion criteria: patients with 1°, 2A° hand burns, when operative treatment was not necessary; patients with 3° hand burn; patients sustained airway burn; severe secondary diseases (cardiovascular or pulmonary diseases accompanied by severe insufficiency and decompensation of these systems, uncorrectable coagulopathy, serious CNS and psychical diseases). Also patients younger than 18 years were excluded from the study.

The studied patients were divided into two groups by the envelope method. Necrectomy and immediate split thickness skin grafting were performed on group A patients during the first 7 days after the burn injury. During the period to the operation silver sulfadiazine cream applications were performed daily. After the operation the skin graft was coated with paraffin net bandaging every third day. Daily silver sulfadiazine cream application was performed on patients in group B till epithelization of the wound. If during 14-day period there was no epithelization of the wound – delayed necrectomy and grafting were performed. Patients were discharged from the hospital when wounds were completely healed and when dressings were unnecessary.

We have analyzed early and remote results of hand function. The analysis of data was performed using Statistica 5.0 (StatSoft Inc., USA) programme package. We analyzed the hypothesis of normal variable distribution with the Shapiro–Wilk test. Having been ascertained the normal distribution of variables the differences were compared using Student’s t-test – the criterion among independent samples. We applied the paired Student’s t-test while comparing the changes of hand function of the same patients during the periods of 3 and 12 months. Hypothesis about the parity of distribution of qualitative variables between the groups were analyzed with the nonparametric chi square (χ²) criterion or the Fisher’s exact test, depending where they were appropriate. The subordination of quantitative variables from other factors was investigated using models of the multiple regression. The level of statistical significance was set at p value <0.05.

**Results**

*Evaluation of the deficiency of the function*

Estimating the deficiency of the function we calculated the deficiency of function of every joint in degrees. Later we shifted this information into the terms of percentage of the joint deficiency and calculated separate the deficiency of function of every finger, hand and arm, emerged after hand and wrist burn. We calculated the deficiency of hand and arm functions after 3 and 12 months. After comparing the deficiency of hand function in both, A and B groups, we ascertained that the deficiency in group A was statistically significantly lower in both examined periods – 3 and 12 months after the injury (Table 1).

After the investigation of the deficiency of hand and arm functions in periods of 3 and 12 months we analyzed how this deficiency changed during the time. Comparison of the deficiency of hand and arm functions during periods of 3 and 12 months showed that the deficiency decreased over time (Fig. 1). After the period of 12 months the deficiency of hand and arm functions was statistically significantly lower than after the period of 3 months after the injury (p<0.05).

The deficiency of hand function in group B was 23%, arm – 26.5% while the deficiency of hand and arm function in group A was 12%.

We have studied the factors that influenced the deficiency of hand function. Applying the model of linear regression we ascertained that the deficiency of hand function because of the wrist and hand burns depends on the age of patient, the area of hand burn, the time from injury to hospitalization and time period to the operation (Table 2).

The deficiency of arm function during the long period may be forecasted by formula:

\[
\text{The deficiency of arm function} = -6.57 + 0.24 \times \text{age} + 0.04 \times \text{time to the hospitalization} + 0.14 \times \text{the burned area of hand} + 0.34 \times \text{time to the operation}\ (r^2 = 0.3944).
\]

*The investigations of digits and arm strength*

During every examination (after the periods of 3 and 12 months) we examined the strength of digit pinch and hand grasp. After we measured the strength of the digit pinch and hand grasp after the 3-month period we ascertained, that it was statistically significantly larger in group A (Table 3).
Table 1. The comparison of hand function in groups A and B during the periods of 3 and 12 months

<table>
<thead>
<tr>
<th>Insufficiency of the hand</th>
<th>Group A</th>
<th>Group B</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 months after injury</td>
<td>Active</td>
<td>24.73±2.19</td>
<td>42.56±2.08</td>
</tr>
<tr>
<td></td>
<td>Passive</td>
<td>21.47±2.66</td>
<td>45.26±2.60</td>
</tr>
<tr>
<td>12 months after injury</td>
<td>Active</td>
<td>11.83±1.41</td>
<td>23.36±1.98</td>
</tr>
<tr>
<td></td>
<td>Passive</td>
<td>7.2±1.33</td>
<td>17.3±1.85</td>
</tr>
</tbody>
</table>

Table 2. The results of the forecast of the deficiency of hand and arm function, obtained by applying the method of linear regression

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Standardized regression criterion ( \beta )</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.24</td>
<td>0.02</td>
</tr>
<tr>
<td>Area of the burned hand</td>
<td>0.14</td>
<td>0.001</td>
</tr>
<tr>
<td>Time to hospitalization</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>Time to surgical procedure</td>
<td>0.34</td>
<td>0.049</td>
</tr>
</tbody>
</table>

The strength measured 12 months after the injury in groups A and B was larger than that measured 3 months after the injury. Like 3 months after the injury it was statistically significantly larger in group A (Table 4).

Analyzing the hand function the strength of digit pinch and hand grasp was also measured. The strength of the grasp regenerated quite badly in both groups of males and females (Table 5). The strength of the grasp in males in group A regenerated up to 76% while in females – up to 61% of norm. The results of group B were even worse – 60.8% for males and 39.36% for females. The pinch strength for males and females regenerated earlier in group A and it was close to the norm after 3 months. After the period of 12 months the strength of digit pinch for males and females in both groups exceeded the norm.

**Discussion**

There is no general opinion how to treat patients sustained deep partial-thickness hand burns. Some authors offer to perform early necrectomy and grafting with skin grafts (4, 9–14). Others suggest waiting for the separation of necrotic tissue and spontaneous epithelization or performing grafting to cover the settled granulated tissue in case if wounds would not heal up (11, 15, 16). Using one or another method during the repair of wounds the scar forms which hypertrophies and the contractures of wrist and digits joints occur (17–20). Because of a rough scar the

Table 3. The comparison of the strengths of digits and hand in groups after the period of 3 months

<table>
<thead>
<tr>
<th>Category</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
<td>Group B</td>
</tr>
<tr>
<td>Pinch strength I to II (kg)</td>
<td>4.55±0.43</td>
<td>2.85±0.38</td>
</tr>
<tr>
<td>Pinch strength I to II–III (kg)</td>
<td>6.19±0.61</td>
<td>3.67±0.48</td>
</tr>
<tr>
<td>Key pinch strength (kg)</td>
<td>8.00±0.72</td>
<td>4.96±0.50</td>
</tr>
<tr>
<td>Grasp strength (kg)</td>
<td>25.42±1.99</td>
<td>14.07±1.88</td>
</tr>
</tbody>
</table>

Table 4. The comparison of the strength of digits and arm after the period of 12 months

<table>
<thead>
<tr>
<th>Category</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
<td>Group B</td>
</tr>
<tr>
<td>Pinch strength I to II (kg)</td>
<td>7.35±0.53</td>
<td>5.52±0.54</td>
</tr>
<tr>
<td>Pinch strength I to II–III (kg)</td>
<td>8.77±0.72</td>
<td>6.15±0.57</td>
</tr>
<tr>
<td>Key pinch strength (kg)</td>
<td>10.32±0.75</td>
<td>8.04±0.55</td>
</tr>
<tr>
<td>Grasp strength (kg)</td>
<td>35.74±2.02</td>
<td>28.59±3.01</td>
</tr>
</tbody>
</table>
Table 5. The changes of the strength of digit pinch and hand grasp in groups A and B after the periods of 3 and 12 months (percentage of norm)

<table>
<thead>
<tr>
<th>Category</th>
<th>Males</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 months after injury</td>
<td>12 months after injury</td>
<td>3 months after injury</td>
<td>12 months after injury</td>
</tr>
<tr>
<td>Grasp strength in group B</td>
<td>29.94</td>
<td>60.84</td>
<td>14.54</td>
<td>39.36</td>
</tr>
<tr>
<td>Grasp strength in group A</td>
<td>54.08</td>
<td>76.05</td>
<td>30.26</td>
<td>60.99</td>
</tr>
<tr>
<td>Key pinch in group B</td>
<td>66.17</td>
<td>107.16</td>
<td>28.89</td>
<td>71.11</td>
</tr>
<tr>
<td>Key pinch in group A</td>
<td>106.67</td>
<td>137.63</td>
<td>65.19</td>
<td>111.11</td>
</tr>
<tr>
<td>Pinch I to II–III in group B</td>
<td>65.48</td>
<td>109.79</td>
<td>31.25</td>
<td>59.52</td>
</tr>
<tr>
<td>Pinch I to II–III in group A</td>
<td>110.60</td>
<td>156.68</td>
<td>69.44</td>
<td>115.08</td>
</tr>
<tr>
<td>Pinch I to II in group B</td>
<td>53.81</td>
<td>104.12</td>
<td>22.01</td>
<td>48.74</td>
</tr>
<tr>
<td>Pinch I to II in group A</td>
<td>85.82</td>
<td>138.77</td>
<td>58.70</td>
<td>117.40</td>
</tr>
</tbody>
</table>

Fig. The changes of the deficiency of hand and arm function after the periods of 3 and 12 months

The changes of the strength of digit pinch and hand grasp in groups A and B after the periods of 3 and 12 months (percentage of norm)

The amplitude of fingers and wrist motions declines and this causes the deficiency of hand function. Even the immobilization of the injured hand in a function position, the kinesitherapy procedures, the silicone products, pressure bandage or other means impeding the hypertrophy of the scar cannot protect from the complications mentioned earlier.

There are very contradicting data in the analysis in the different literature. In some literature sources it is pointed out that the results of function analysis will be the same using one or another method (16, 21). In other studies there was no statistically significant difference although one method was presented as preeminent (22). There is no general method for studying the hand function and it is difficult to compare the results presented in the literature.

Evaluating the general function of hand and arm we used recommendations of the American Hand Surgeon Association, the American Orthopodist Academy and the American Medical Association and analyzed the deficiency of hand and arm functions. Unfortunately, we could not find any investigation in the literature analyzing the deficiency of hand function in patients who sustained hand burns by this method. Some authors calculate the general amplitude of digit motions analyzing the hand function. This is an objective method evaluating the hand function, but using this method it is impossible to evaluate the disorder of wrist movements. Using this method one can evaluate objectively the deficiency of hand function, moreover, it is possible to evaluate the deficiency of arm function emerged after hand or wrist injury.

We calculated the deficiency of hand and arm function after the periods of 3 and 12 months and ascen-
tained that the deficiency in group A was statistically significantly lower in both examined periods – 3 and 12 months after injury. After the period of 12 months the deficiency of hand and arm functions was statistically significantly lower than after the period of 3 months after injury. Although the hand function improved over the time but even after the period of 12 months the deficiency of hand and arm functions was still obvious. The deficiency of hand function in group B was up to 23% and the deficiency of arm function was up to 26.5%. This means that 1/4–1/5 of past function did not regenerate. Meanwhile, the deficiency of arm and hand function in group A was up to 12%. Although the results were better in group A but the function did not regenerate completely. These reasons encourage searching new healing methods enabling to regenerate the function of burned hand better.

Studying the function of hand we also investigated the strength of digit pinch and hand grasp. According to the literature the strength of dominant and non-dominant hands differs just for 4–8% of examined persons. Appealing to this material we calculated the strength of digit pinch and hand grasp of dominant and non-dominant hands together and compared it within groups A and B. After the searching in PubMed and Cochrane Library databases we found just one study where the results of strength measurements were presented. In other studies there is just mentioned that hand function regenerated perfectly, good or badly (22). In the study of M. M. Covey (1987) it is stated that the normal hand strength regenerated in 93% of the patients.

After the periods of 3 and 12 months we investigated the strength of digit pinch and hand grasp. After we measured the strength of digit pinch and hand grasp we ascertained, that it was statistically significantly larger in group A. The strength measured 12 months after the injury in groups A and B was larger than that measured 3 months after the injury. The strength of the grasp regenerated quite badly in both groups of males and females. During the evaluation of the strength we stated that both the strength of digit pinch and hand grasp was larger in group A in both examined periods. We also ascertained that the strength regenerated better after the 12-month period and the worse results were obtained 3 months after the injury.

These results show that none of these treatment methods is perfect. Therefore, other healing methods, which could regenerate the strength of digit pinch and hand grasp, the general hand function and efficiency, must be searched.

Conclusion
During the perspective analysis it was determined that after periods of 3 and 12 months after injury the strength of digit pinch and hand grasp was statistically significantly larger in group of early necrectomy and plasty group, while the deficit of hand function in this group representing the general hand function was statistically significantly lower.

Nudegusių plaštakų funkcijos analizė lyginant ankstyvąją nekrektomiją ir plastiką bei atidėtą gydymą

Kęstutis Maslauskas, Rytis Rimdeika, Jolita Rapolienė1, Tadas Ramanauskas1
Kauno medicinos universiteto Chirurgijos klinika, 1Kauno medicinos universitetas

Raktažodžiai: plaštakos sužalojimas, plaštakos nudegimas, nudegusios plaštakos gydymas, plaštakos funkcija.

Santrauka. Tyrimo tiklas. Apžvelgti plaštakos funkcijos rezultatus suaugusių pacientų, patyrusių plaštakos dalinio storio odos nudegimus. 


Nustatyta, jog rankos funkcijos deficitas, atsiradęs dėl riešo ir plaštakos nudegimo, priklauso nuo paciento amžiaus, plaštakos nudegimo ploto, laiko nuo susižalojimo iki atvykimo į stacionārą ir laiko iki operacijos.

Pirštų gnybio ir plaštakų griebimo įgūda po 3 ir 12 mėnesių didesnė buvo A grupėje. Praėjus 12-kai mėnesių nuo nudegimo, išmatuota jėga A ir B grupėse buvo didesnė negu po 3 mėnesių. Vyrams A grupėje plaštakų

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Išvados. Perspektivyiojo tyrimo metu nustatyta, jog, tariant po 3 ir 12 mėnesių nuo nudgegimo, gnybio ir griebimo jėga statistiškai reikšmingai didesnė buvo A grupe. Plaštakos bendrajį funkcinį rodantis plaštakos funkcijos deficitas statistiškai reikšmingai mažesnis buvo A grupei.

Adresas susirašinėti: K. Maslauskas, KMUK Chirurgijos klinika, Eivenių 2, 50009 Kaunas
El. paštas: m.kestas@one.lt

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