

Post-burn sequelae of the hand in children

Les séquelles de brûlures de la main chez l'enfant

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ABSTRACT

The hand is often exposed to burn injuries. Post-burn sequelae of the hand in children are frequent. They are mainly functional. We conducted a retrospective study of post-burn sequelae of the hand in children at the Paediatric Orthopaedic and Reconstructive Surgery Department of the Children's Hospital in Rabat, from January 2000 to December 2016. The aim was to illustrate the epidemiological, etiological and clinical aspects of sequelae, the therapeutic methods used during surgery and their results. Our study comprised of 61 children. 67 injured hands were reported in total. The average age was three years and four months. The sex ratio was one point nine and predominantly male. Almost all of the post-burn sequelae of the hand were adhesive contractures, and were sometimes associated with other types of sequelae. Various surgical methods were used: Z-plasty, skin graft and local flaps. Post-operatively, all our patients were immobilized and benefited from functional

Conflit d'intérêt : Les auteurs ne déclarent aucun conflit d'intérêt en rapport avec la rédaction de cet article.

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rehabilitation. 73,8% of the children had excellent results with quasi-complete functional recovery of the initially contracted area. Post-burn sequelae of the hand in children pose a real public health problem. Only the prevention of burn injuries and an adequate management in the acute phase of the burns, can reduce the frequency of these sequelae.

Keywords: Post-burn sequelae, Hand, Child, Adhesive contractures, Surgery.

RESUME

La main est souvent exposée aux brûlures. Les séquelles de brûlures de la main chez l'enfant sont fréquentes. Elles sont principalement d'ordre fonctionnel. Nous avons mené une étude rétrospective des séquelles de brûlures de la main chez l'enfant, au service de Chirurgie Reconstructive et Orthopédie pédiatriques de l'Hôpital d'enfants de Rabat, entre Janvier 2000 et Décembre 2016, afin d'illustrer les aspects épidémiologiques, étiologiques, cliniques et les procédés thérapeutiques utilisés en chirurgie séquellaire et leurs résultats. Notre série comportait 61 enfants, avec 67 mains lésées. L'âge moyen était de trois ans et quatre mois. Le sex-ratio de 1,9 en faveur du sexe masculin. La quasi-totalité des séquelles de brûlures de la main était des brides rétractiles, parfois associée à d'autres types de séquelles. Différents moyens chirurgicaux ont été utilisés : plasties en Z, greffes de peau et lambeaux locaux. En post-opératoire, l'ensemble des enfants a bénéficié d'une immobilisation et d'une rééducation fonctionnelle. Les résultats post-opératoires étaient jugés excellents-bons chez 73,8% des enfants, marqués par une récupération fonctionnelle quasi-

complète de la zone rétractée initialement. Les séquelles de brûlures de la main chez l'enfant, constituent un véritable problème de santé publique. Seule la prévention des accidents de brûlures ainsi qu'une bonne prise en charge au stade aigu des brûlures, permettent de réduire la fréquence de ses séquelles.

MOTS-CLÉS : Séquelles de brûlure, Main, Enfant, Brides rétractiles, Chirurgie.

INTRODUCTION

The hand is often exposed to burn injuries. Post-burn sequelae of the hand in children are frequent. They are mainly functional and impede the growth of the affected limb. The aim of our study is to illustrate the epidemiological, etiological and clinical aspects of sequelae surgery, as well as the therapeutic methods used and their results.

MATERIALS AND METHODS

This is a retrospective study comprising of 61 children under the age of 15 years who presented principally with 67 injured hands in total and functional impairment. They underwent surgery for post-burn sequelae of the hand at the Paediatric Orthopaedic and Reconstructive Surgery Department of the Children's Hospital in Rabat, from January 2000 to December 2016.

RESULTS

EPIDEMIOLOGY

Our study included 21 girls (34%) and 32 boys (66%). The male/female sex ratio was one point nine, predominantly male, regardless of the age group. Almost all patients came from low-income backgrounds.

The average age was three years and four months, with extremes ranging from two months to 14 years. The majority of children with burns were under four years, and the ages most affected ranged from two

months to two years, with a total of 23 cases (37.7%).

All burn sequelae resulted exclusively from thermal burns mainly caused by hot liquids; boiling water was often incriminated, as shown in Table 1.

Table 1. Causes of burn injuries

Causative agent	Number of cases	Percentage %
Hot liquid	25	41
Flame	18	29,5
Ember	4	6,5
Electricity	11	18
Other	3	5
Total	61	100

CLINICAL ASPECTS

Post-burn sequelae of the hand are mostly functional and scarring. In 50 cases (82%), burn injuries affected just the hands while in five cases, the wrist was also affected (eight point two percent). We noted other associated lesions in six cases (nine point eight percent). The various injuries are detailed in Tables 2 and 3.

Table 2. Burn injuries involving the hand

		Number of cases	Percentage %
Hand involvement	Unilateral	55	90
	Bilateral	6	10
The affected hand	Right	20	36,4
	Left	25	45,4
	Unspecified	10	18,2
The affected side of the hand	Palmar	51	83,6
	Dorsal	5	8,2
	Both	4	6,6
	Ulnar slope	1	1,6

Table 3. Burns injuries of the fingers

Finger injury		Number of cases	Percentage %
Unique finger injury	1 st finger or thumb	2	13,3
	2 nd finger or index	3	20
	3 rd finger or middle	3	20
	4 th finger or ring	1	6,7
	5 th finger or little	6	40
Multiple finger injuries	2 fingers	15	34
	3 fingers	9	20,5
	4 fingers	9	20,5
	5 fingers	11	25
Absence of finger injury		2	3,3

Different types of sequelae were observed in our study. Adhesive contractures were by far the most predominant. Depending on whether one or both hands were affected, we noted the following (see Table 4):

THERAPEUTIC ASPECTS

The average age of the first consultation was four years and ten months (extremes ranging from ten months to 15 years).

To correct deformities, 92 surgical procedures were performed for sequelae of hand burns, associated with six surgical procedures for sequelae in other locations.

The aim was to remove adhesive contractures and repair ensuing substance loss in order to regain a normal function of the hand.

The average age for surgery was five years and nine months (extremes ranging from ten months to 14 years).

The average time between the burn accident and the first surgery was two years and 11 months (extremes ranging from six months to 13 years and seven months).

Table 4. Post-burn sequelae

	Types of sequelae	Number of cases	Percentage %
Hands only (50 cases)	Isolated adhesive contractures	35	70
	Adhesive contractures + Hypertrophic scars	1	2
	Adhesive contractures + Deformity	3	6
	Adhesive contractures + Amputation	5	10
	Adhesive contractures + Syndactyly	5	10
	Neuroma	1	2
	Hands and wrist (5 cases)	Isolated adhesive contractures	2
Adhesive contractures + Atrophic Scars		2	40
Adhesive contractures + Amputation		1	20
Hands and associated lesions (6 cases)	Isolated adhesive contractures	2	33,3
	Adhesive contractures + Hypertrophic scars	3	50
	Adhesive contractures + Amputation	1	16,7

Table 5. Various surgical modalities

		Number of cases
Number of surgical procedures	A single surgical procedure	35
	2 surgical procedures	18
	> 2 surgical procedures	8
Main surgical procedures	Cutaneous plasty (Z-plasty)	10
	Cutaneous plasty + Total skin grafts	32 (1 case: composite graft)
	Cutaneous plasty + Skin flaps (latero-digital)	4
	Cutaneous plasty + Total skin grafts + Latero-digital flaps	10
	Local flaps + Skin grafts	4
Other surgical procedures	Pinning	27
	Tenolysis at the digital sheath	3
	Arthrodesis - Chondrodesis in the thumb and the MCP joint	3
	Interphalangeal arthrolysis	3
	Rectification of the nail (medius)	1
	Osteotomy of the thumb	1
	Reduction of thumb dislocation	1
	Elongation of the extensor muscles	1
	Tendinous transfer for 2-step tendon reconstruction of the flexor muscle	1

Some of the children required several surgical procedures. The most widely used procedures were skin plasties, Z-plasties and latero-digital flaps. 46 skin graftings were performed with the hypothenar region being the preferred site for skin graft sampling. A composite graft removed from the arch of the foot was used in one patient.

The management of post-burn sequelae included other surgical procedures allowing optimization of the final result (Table 5).

Postoperatively, all our patients were immobilized in the position of maximum skin capacity for complete healing. They also underwent functional rehabilitation.

EVOLUTIONARY ASPECTS

The average follow-up was two years and eight months with extremes of seven months and nine years.

The therapeutic evaluation depended mainly on the functional results (Table 6). Results were judged:

Excellent - Very good: i.e. total anatomical and functional recovery of the hand and a subnormal cosmetic appearance.

Good: i.e. acceptable hand function, and the absence of adhesive contractures in the functional areas of the hand despite the persistence of a slightly acceptable scarring dyschromia.

Average: i.e. improvement over the initial state with a persistence of slight retraction. Complementary manoeuvres are essential to improve the function of the affected hand. There are disfiguring scars.

Poor: i.e. lack of improvement or insignificant improvement in relation to the previous state, indicating treatment failure with disfigured and fragile scars.

Table 6. Therapeutic results

Therapeutic Results	Number of cases	Percentage %
Excellent / Very good	25	41
Good	20	32,8
Average	10	16,4
Poor	6	9,8
Total	61	100

We illustrate by the following images some cases operated at the Paediatric Orthopaedics and Reconstructive Surgery Department of the Children's Hospital in Rabat, by the senior author Amrani A. (Fig. 1 to 15):



Fig 1 (a and b). Digito-palmar adhesive contracture of the thumb with an adhesive contracture of the index finger and anterolateral deviation
Fig2. Intraoperative treatment of the adhesive contracture by a composite graft
Figure 3. Post-operative image

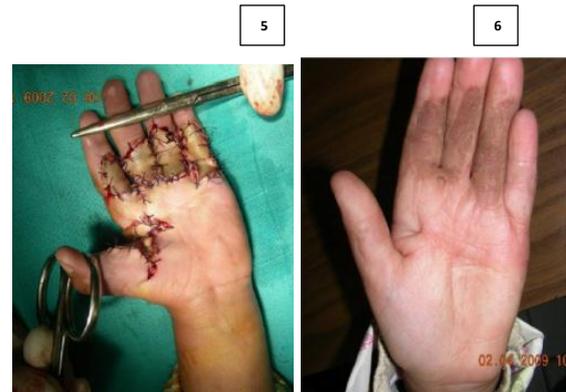
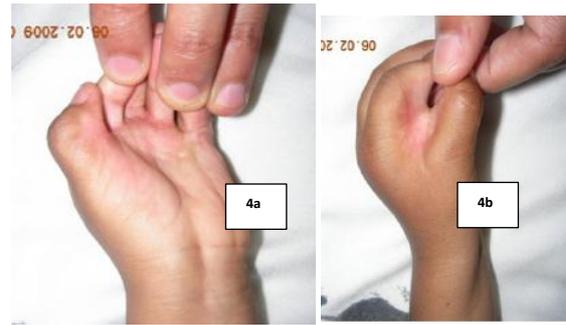
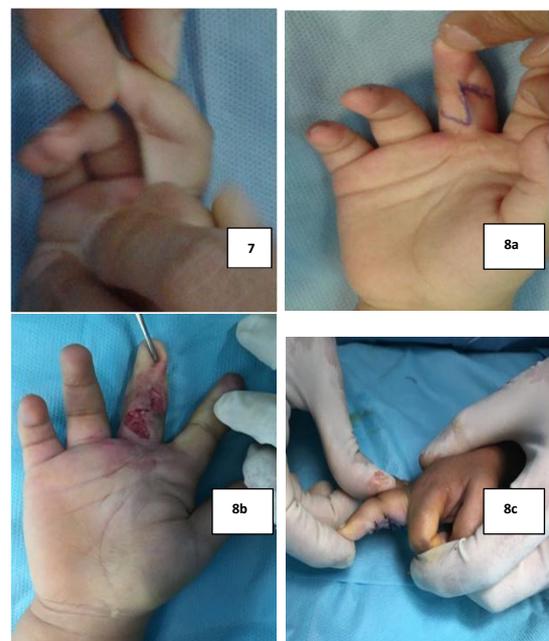


Figure 4 (a and b). Digito-palmar adhesive contractures of four fingers with syndactyly of the first commissure
Figure 5. Intraoperative treatment of the adhesive contracture by total skin graft
Figure 6. Post-operative image showing dyschromia of the index, middle and ring fingers



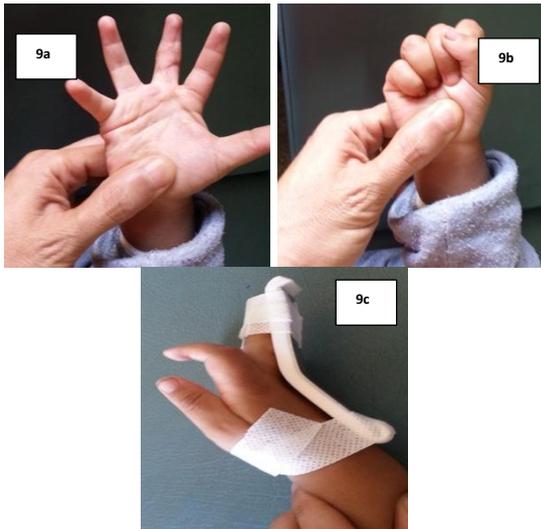


Figure 7. Adhesive contracture of the middle finger
Figure 8 (a, b and c). Intraoperative treatment of the adhesive contracture by Z-plasty
Figure 9 (a, b and c). Post-operative image showing the use of a malleable static splint

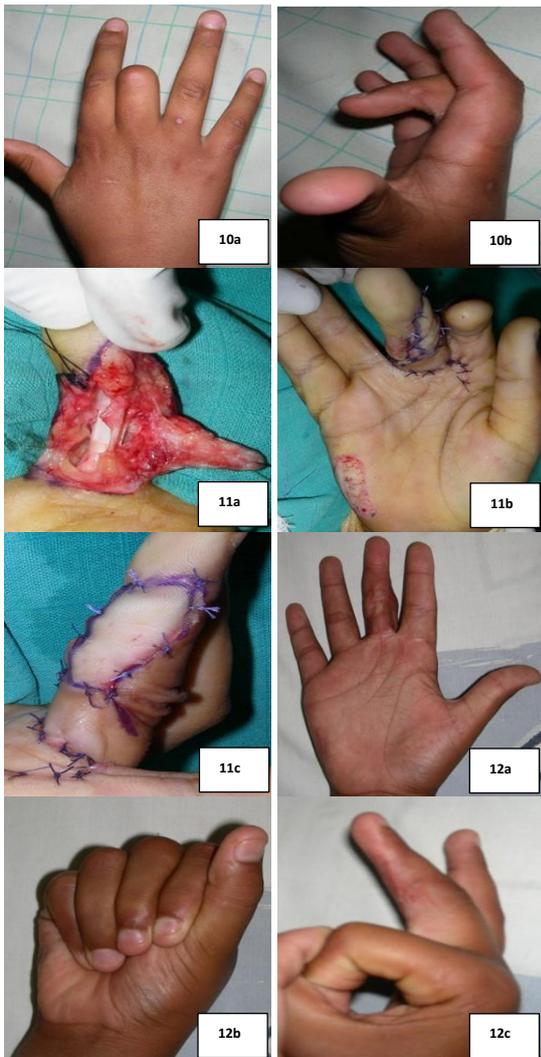


Figure 10 (a and b). Adhesive contractures of the middle finger

Figure 11 (a, b and c). Intraoperative image showing the treatment of the adhesive contracture by latero-digital local flap

Figure 12 (a, b and c). Post-operative image



Figure 13 (a and b). Digital retraction of the little finger

Figure 14 (a and b). Intraoperative image showing the treatment of the retraction by latero-digital local flap

Figure 15 (a, b and c). Post-operative image

DISCUSSION

Epidemiology

According to data from WHO, burn injuries account for more than 300 000 deaths per year. Because of their frequency and

complications, they pose a major public health problem globally, especially in low- and middle-income countries. Deaths are only part of the problem. For every person who dies from burns, many more are left with lifelong disabilities and disfigurements (1-3).

In Morocco, burn injuries represent two percent of emergency admissions at university hospitals (4).

Children are the main victims of burns (5). The average age in our study was three years and four months, and the majority of children suffering from burn injuries were under the age of four years. This average age is similar to those reported in the literature (4,6), mostly by authors Sankale (7) and Goffinet (8). Also, the majority of the authors found that burns occurred in children under the age of five years. Burns in early childhood, and especially of the hands, parts of the body exposed and unprotected against various aggressive agents (9), can be explained by several factors (10-13): learning to walk, exploration of the world through touch, carelessness of the youth, ignorance of risk, and the lack of vigilance by parents in the supervision of their children. Moreover, preventing domestic accidents relies on the parents.

Results collated from our study and review of the literature revealed a predominantly male to female sex ratio (7,14-17). Sankale (7) explains this predominance by the turbulence of boys and their lack of awareness of danger.

All the children in our series were from low-income families, as is the case with findings in the literature. Some explained that the occurrence of burns and their sequelae is due to overcrowded homes and the absence of safety measures. Also, the lack of information in rural areas and the difficult access to hospitals contribute to the increase

of these accidents and their sequelae (7,6,13).

All post-burn sequelae in our study resulted exclusively from thermal burns mainly caused by hot liquids (boiling water). Our results are consistent with some studies conducted in other countries (3,4,6,15,18). This resulted from the accidental sprinkling of boiling liquid directly onto the child's hand. The second thermal cause were flames, especially butane flames. Lastly, burn injuries resulting from the child handling electrical devices or biting into an electrical extension cord plugged into an outlet were also noted.

It can be inferred that exposure to a causal agent has certain cultural specificities. Scalding burns are frequent because of promiscuity, with recklessness and maternal errors during culinary preparation (tea, soup, etc....) and bathing at home or in the Moorish bath. Also, their frequency increased during the summer, which coincides with the holy month of Ramadan. Butane flame burns are often collective and associated mainly with errors in the use of small three kilograms gas cylinders due to their paradoxical accessibility and looseness (4,12).

However, other studies revealed other predominance, according to the frequent use of each causative agent. For example, in Senegal and in the Democratic Republic of Congo (7,16), thermal burns by fire and flames were predominant due to their use for heating, lighting and cooking. In India (17), electricity-related burns were more frequent due to the lack of appropriate safety measures for electrical installations and exposed wires.

Post-burn sequelae secondary to chemical burns were absent in our study. In the literature, chemical burns were either absent or present but insignificant, not exceeding one percent (6,15).

It should not be forgotten that the mechanism of burns differs according to age. The child is more often injured by hot fluids, while an adult is more often than not victim of burns by flames (4,19).

Clinical aspects

The hand is the organ most affected by burns whatever the causative agent. Burns affecting the hand are therefore a criterion of gravity, especially in children, because of the functional and aesthetic sequelae that they generate, associating adhesive contractures and digital stiffness, even amputations in extreme cases. A good initial management comprising of early surgery, maximum skin capacity immobilization and functional rehabilitation, remains the best prevention of sequelae, which are mainly cutaneous and rarely osteoarticular (20-23).

Burn to the dorsal side of the hand is more severe due to the nature of the skin, possible exposure of tendinous elements and insufficient venous drainage. The palmar skin is thicker. Palmar burn is severe in infants who leave their hands in contact with a heat source, unlike in children over three years old who quickly withdraw their hands from the heat source (11).

In our study, palmar burns were predominant, regardless of the age group. Our results concur with those found in literature (3,7,10,11,23). Benbrahim (24) found that in his study, the dorsal side of the hand was mainly affected. This can be explained by the addition of adult patients in the study.

We found that all our patients had injuries to their fingers. In the case of only one finger been affected, it was the little finger as opposed to the middle finger according to Coulibaly and Boukind (3,23). Compared with the literature, our results were similar to those of Gupta (17) regarding injuries to more than one finger.

Concerning commissural involvement, the 1st commissure constitutes a risk location [8], hindering the thumb-index grip. This involvement was present in 35% of our patients versus 19% of those in the Boukind study (23).

Adhesive contractures are the main type of hand-burn scalding. These were present in almost all our patients, regardless of their locations on the hand. Our results are similar to those found in the literature. The authors (3, 7) explain this predominance by the poor initial management of burn injuries. Either the patient, and in the case of the child, his family, underestimates the frequency of adhesive contractures and ignores the importance of being treated in the hospital, preferring treatment at home by using animal fat or medicinal plants, or the hospital where the patient was first seen lacks adequate methods for proper management of functional areas (maximum skin capacity immobilization and early rehabilitation), thus favouring abnormal postures. Only Kibadi (16) reported a high rate of hypertrophic scars and keloids explaining that these sequelae were the prerogative of blacks.

THERAPEUTIC ASPECTS

The treatment of post-burn sequelae of the hand is extensive, which requires the use of surgical and medical techniques. Surgical management is difficult due to the diversity of the sequelae. Indeed, each burn victim is a stand-alone case. To provide adequate treatment, health professionals must work in close collaboration. The aim is to remove adhesive contractures and repair ensuing substance loss in order to regain normal function of the hand. Also, the timing of post-burn sequelae management influences the final outcome.

In our study, almost all patients had cutaneous plasty, either done alone or often associated with other surgical procedures, which mainly involved total skin grafts and

lateral-digital skin flaps. Z-plasty played a pivotal role in the management of post-burn sequelae of the hand.

Our therapeutic procedures were similar to those found in the literature, but at variable rates(3,5,7,17).

However, Z-plasty combined with skin graft is the best choice in reconstructive surgery for post-burn sequelae of the hand (25, 26).

Cutaneous plasties are simple and effective procedures for treating adhesive contractures or contractures between healthy and pathological skin, using transposition or translational skin flaps. Z-plasty represents the base treatment for adhesive contractures (27-30).

Skin grafts are essential in the surgical management of post-burn sequelae. In children, total skin grafts satisfy all the indications, allowing for good grafting and especially reducing the occurrence of scar retractions, which are frequent with thin skin grafts.

However, care must be taken in correctly choosing the sampling site which preferably remains the hypothenar region (31-35).

However, both Sankale (7) and Boukind (23) praised the benefits of total skin graft in the management of post-burn sequelae of the hand and the finger, explaining their choice by the excellent results they had and highlighting especially the important loss of cutaneous substance after removing adhesive contractures, which can only be restored by skin graft.

Skin flaps (27, 28, 32, 36, 37) are indicated whenever a vascularized tissue is needed or a noble organ is injured. These constitute strenuous surgery. The best management of post-burn sequelae of the hand and especially in the child involves simple, easy and reliable techniques.

Postoperatively, immobilization in maximum skin capacity and functional rehabilitation are used in order to optimize the outcome of the surgical treatment.

The immobilization (8,32,38) in maximum skin capacity allows for good grafting and the non-recurrence of local contractures. This is done by the use of orthoses or splints four to 24 hours a day for several weeks or even several months.

Functional rehabilitation (36) is commenced after healing, through active and passive mobilization aimed at restoring and maintaining joint amplitudes, as well as preventing and avoiding tissue retraction.

A properly administered postoperative management leading to excellent results is praised by all the authors (3,16,23).

EVOLUTIONARY ASPECTS AND RESULTS

The average follow-up was two years and eight months with extremes of seven months and nine years.

For Sankale (7) and Kibadi (16), average follow-up was 18 months and less than six months respectively, which is insufficient for a good evaluation.

Alexander (39) explains that the best evaluation can only be carried out after two years of follow-up which coincides with the development of postoperative sclerotic tissue.

The average follow-up in our study reflects the surgeon's interest in the follow-up of the child with burn injuries throughout his/her developmental stage, and parent participation in the well-being of their child.

Our results were judged based on the functionality of the hand. 73.8% of the children had excellent / good results, with an acceptable or even total recovery of hand function, providing patients with autonomy

in hand movements. Generally, our results were similar to those found in the literature (3,7,16,23).

Aesthetically, the majority of the results were satisfactory. According to Dhenin (40), cosmetic results, though qualified as good, cannot meet the expectations of both patient and surgeon. His opinion is supported by Baux (41) who underscored the fact that whatever the therapeutic possibilities are, scarring will occur, aesthetically at least.

CONCLUSION

Burns are common accidents in early childhood, resulting in sequelae in the absence of treatment or inadequate initial management.

Post-burn sequelae of the hand are particularly frequent, and they pose a real public health problem. Their severity is more functional than cosmetic. The surgical methods used in the management of post-burn sequelae of the hand in our study were Z-plasty, skin graft and local flaps. Postoperatively, immobilization in maximum skin capacity and functional rehabilitation assure rapid and adequate functional recovery.

The aim of our study was to illustrate the benefit of management in the acute phase of burns, which must be multidisciplinary and carried out under good conditions in order to ensure better scarring and complete healing, as well as reduce the frequency and severity of post-burn sequelae of the hand.

However, only the prevention of burn injuries can reduce the frequency of these sequelae.

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