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ARTICLE

Reconstruction of postburn contractures due to tandir oven

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ABSTRACT

The aim of the study was to evaluate postburn contracture reconstructions caused by high temperature such as tandir. The records of our 58 patients who were operated for burn contracture between 2008 and 2018 were retrospectively reviewed. Duration elapsed after the burn, localization of contracture, surgery applied, and the recurrence rates were recorded. McCauley classification was used to evaluate the severity of hand contractures. One hundred and thirty-seven contracture release operations were performed in 45 hands in 40 cases. Five patients had bilateral hand contractures. One hundred and sixty-three (84.9%) surgeries out of total 192 contracture release surgery were applied to the hand and foot region. FTSG alone was the most common method of treatment. Z-plasty was used the most frequently by our team as the flap surgery. Tissue damage is more severe due to very high temperature of the tandir and as a result, more frequent and heavier burn contracture occurs on hands and feet than other burn etiologies develops, and reconstructive operations are needed more frequently.

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Introduction

Humankind has used fire to illuminate, warm up, and to cook food throughout history since its discovery. Although billions of people today use natural gas and electricity for these needs, fire is still used in underdeveloped and developing countries. Tandir, a traditional oven, is still widely used in a wide geography from Turkey to Tibet in Asia [1,2]. This oven, called tandoor in and around India, is used to warm up, make kebabs and specially to bake bread [1]. It has recently gained popularity in both Western and European countries thanks to tourists and hence has migrated to the new world [1]. Dakota hole fire used in North America is a miniature of tandir.

Tandirs work on the same principle, although their sizes and shapes may vary according to the region. It is usually in the form of a well in the room or garden of the house, with a depth of about 150 cm and a diameter of 60 cm. Wood and coal are burned inside it, and it also has a ventilator tube to meet the oxygen demand of the fire (Figure 1). The tandir design incorporates all the primary forms of heat transfer, namely radiation, conduction and convection [1]. Due to its shape like a jug, and the heat concentration within the chamber, its temperature can reach up to 470 °C [1].

Thermal injury continues to be a serious health problem that can lead to morbidity and mortality worldwide [2]. Postburn contractures are the most important causes of morbidity caused by burns. Postburn contractures have a devastating effect on quality of life and ability to perform activities and require surgical treatments such as skin grafting, and the use of local and distant flaps [2]. The frequency and diversity of etiological factors in burn trauma varies depending on the climate, industrialization, socio-economic, cultural and educational characteristics of each region. The classical tandir burns are in the form of people falling into the tandir oven on their hands and feet. Mostly women who cook the food and accompanying children are affected [3] (Figure 2). As temperature increases 10 °C, the severity of damage is doubled [4]. This is due to the fact that the probability of chemical reactions that results in destruction of tissue structures is doubled [4]. Therefore, tandir-related burns that reach high temperature can cause very severe deformities, especially in the hands and feet.

Several clinical studies have been conducted on tandir burns [2,3,5]. However, there is no study reporting late contracture treatments for tandir burns. We therefore focused our study on our experiences of postburn contracture reconstructions caused by high temperature such as tandir.

Materials and methods

The records of our patients who were operated for burn contracture between 2008 and 2018 were retrospectively reviewed. Contractures due to non-tandir burns were excluded from the study. Age and gender of patients, duration elapsed after the burn, localization of contracture, surgery applied, and the recurrence rates were recorded.

All hand surgical procedures were performed under pneumatic tourniquet, and as soon as the wound became available for physiotherapy, all patients were discharged with a dynamic splint. McCauley classification was used to evaluate the severity of hand contractures [6].

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Figure 1. Image of a tandir oven.

Figure 2. Schematic view of tandir.

Results

Fifty-eight cases of surgery for tandir burn-related contracture were identified. One hundred and thirty-seven contracture release operations were performed in 45 hands in 40 cases. Five patients had bilateral hand contractures. Contracture release surgery was performed on 18 cases other than hand localizations (Table 1).

Demographic data

For the patient group in our study, 31 (53.4%) were male and 27 (46.6%) were female. The average age during surgery was 18.6 ± 14.07 years (2–72 years). The average age at the time of the burn was observed to be 7.79 ± 7.17 (1–35 years). The children were the group most affected. 72.4% of the patients were under 10 years of age during injury. 68.75% of those injured after 10 years of age were observed to be women. The mean time to surgery after burn was 10.79 ± 10 years (1–45 years).

Contracture localization

One hundred and thirty-seven contracture release surgery were performed in 45 hands in 40 cases. Most frequently the middle finger was operated upon in the hand region (Table 1). No dominant lateralization was detected in patients. The severity of hand contractures according to the McCauley classification is shown in Table 2. Fifty-five operations were performed on 18 cases other than hand localization. Most commonly the foot, ankle and toes, then the popliteal and neck region were operated upon (Table 1). Also, in one patient, the foot was operated due to syndactyly between first and second toes, while meatomy was performed in one male patient with genital region burns. In one case, the contracture of the ear was loosened with V-Y plasty, and the ear was reconstructed with costal cartilage graft. One hundred and sixty-three (84.9%) surgeries out of total 192 contracture release surgery were applied to the hand and foot region.

Surgical procedures

We made our treatment plan according to the reconstructive ladder (Figure 3). Full-thickness skin graft (FTSG) alone was the most common method of treatment. All split-thickness skin grafts (STSG) and sometimes FTSG were also used as support procedures. Only in the case if the wound bed was suitable for FTSG, then these grafts were applied solo for contracture repair. Z-plasties were used the most frequently by our team as the flap surgery. We also used other local flaps in certain places. We preferred the rhomboid flap especially in the axillary and popliteal region, V-Y plasty in the facial region and V-M plasty and K-M plasty for web space contractures. Designed with the addition of Z-plasty on both long axes of the rhomboid flap, the V-Y-Z plasty allowed us to freely release more serious contractures. After the contracture was released, we used a pedicled flap for moderate defects. In large defects, we reached the last step of the reconstructive ladder and used microsurgical techniques in 13 cases (Table 1).

Joint management

Closed arthrolysis, capsular partial incision and full thickness capsular incisions were performed step by step to achieve the widest range of motion of the joint. Static splints in neutral position and K-wires were used to stabilize the joints. Postoperative management involved dynamic splint as soon as possible. If we have not used free flaps and grafts, second postoperative day active and passive motions of the involved joints were started.

Recurrence

Five cases showed severe recurrence that needed reoperation. One of them had poor access to physiotherapy opportunities. Four other cases were children less than 10 years old. Their families reported their incompliance with the physiotherapy procedure.

Table 1. Tandir burn contracture location and surgical procedures.

Location of contracture	FTSG	STSG	Z-plasty	Rhomboid flap	Multiple Z-plasty	V-Y plasty	K-M plasty	V-M plasty	V-Y-Z plasty	PIO	Free ALT	Free LD	Trapezius	Reverse sural	Total
Foot and finger	14		5								2				21 (38.5%)
Popliteal				5	1		1								7 (12.7%)
Ankle		1	1		1						1			1	5 (9.1%)
Neck					1						1	2	1		5 (9.1%)
Axillary				2					1						3 (5.4%)
Mouth					1	2									3 (5.4%)
Antecubital							1		2						3 (5.4%)
Genital	1				1										2 (3.6%)
Gluteal		1	1												2 (3.6%)
Lower eyelid						2									2 (3.6%)
Canthus							1								1 (1.8%)
Ear						1									1 (1.8%)
Total	15 (27.5%)	2 (3.6%)	7 (12.7%)	7 (12.7%)	5 (9.1%)	5 (9.1%)	3 (5.4%)		3 (5.4%)		4 (7.3%)	2 (3.6%)	1 (1.8%)	1 (1.8%)	55 (100%)
Palmar	5	3	4						1	1		3			17 (12.4%)
Finger 1	4	5	5		1				1						16 (11.7%)
Finger 2	6	7	5		2										20 (14.6%)
Finger 3	11	5	4		2	1									23 (16.8%)
Finger 4	9	5	3	1	2										20 (14.6%)
Finger 5	12	3	2	1	1	1									20 (14.6%)
Web 1							2								2 (1.5%)
Web 2	1						2	2							5 (3.6%)
Web 3		1					2	1							4 (2.9%)
Web 4	1	1					1	1							4 (2.9%)
Wrist	2	1	2												5 (3.6%)
Dorsum												1			1 (0.8%)
Total	51 (37.2%)	31 (22.6%)	25 (18.2%)	2 (1.5%)	8 (5.8%)	2 (1.5%)	7 (5.1%)	4 (2.9%)	2 (1.5%)	1 (0.8%)		4 (2.9%)			137

PIO: posterior interosseous artery flap; ALT: anterolateral thigh flap; LD: latissimus dorsi flap.

Table 2. Classification of tandir burn contractures.

Grade		Hands
I	Symptomatic tightness, no limitation of daily activities	
II	Mild decrease in ROM, mild limitation in daily activities, no distortion	
III	Functional deficit, early changes in architecture	40
IV	Loss of hand function + significant distortion	5
Subset for III, IV		
A	Flexion	38
B	Extension	1
C	Combination of flexion and extension	6

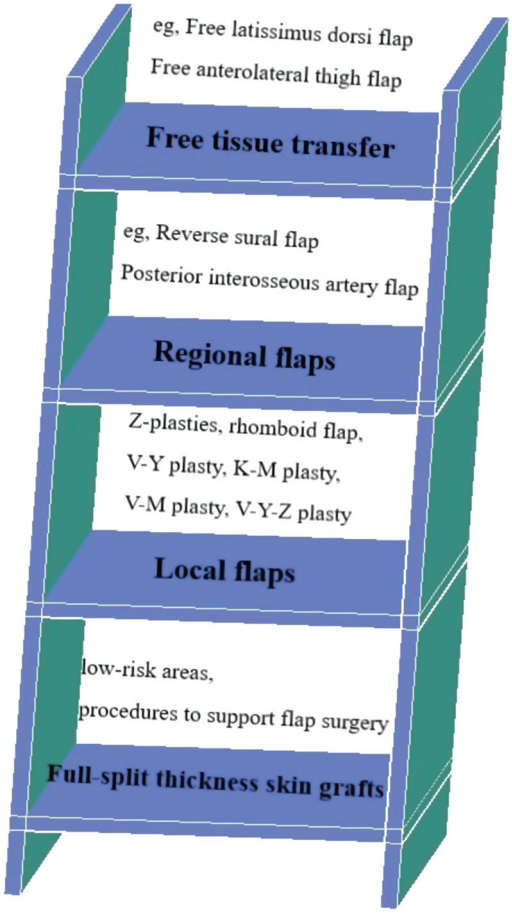

Figure 3. Reconstructive ladder in releases of postburn contractures.

Discussion

Burns are one of the main causes of traumatic injuries in all age groups and may be caused by flame, scalding, electricity, radiation or chemical agents [2]. The diversity and frequency of etiological factors in burn trauma varies depending on the climate, industrialization, socio-economic, cultural and educational characteristics of each region. In developed countries, all of these agents cause variable-intensity burns, but late outcomes, including late-stage deformities, are generally predictable [2].

Tandir, widely used in Asia, is used in rural areas in eastern Turkey [2,5]. The tandir is a well-shaped oven with no protective barrier placed on the ground, so it is possible for children to be injured by falling and burning, and the contact time also has a longer duration, since they cannot get out or be rescued quickly [2,5]. As temperature increases, the severity of tissue damage increases [4,7]. Deep burns damage the skin and often the underlying soft tissue, muscles and bone; therefore, as the depth increases, there is an increased risk of developing joint contracture [8]. Tissue damage is more severe due to the temperature of the tandir rising up to 470 °C [1] and as a result, the treatment of the patient lasts longer than other burn etiologies [3], thus reconstructive operations are needed more often [3]. Likewise, the mortality rate is higher than other burn etiologies [3,5]. If the patient lives, he/she has to cope with severe sequelae in his/her later life.

Like high mortality rate, tandir burn-related amputations are more frequently observed. Albayrak et al. [3] compared non-tandir and tandir burns and reported a mortality rate of 1.3% versus 4.4% respectively. They also found an amputation rate of 1.4% in non-tandir burns versus 17.4% in tandir burns. Akçay et al. [5] stated that the same rates of 4.05% in non-tandir burns versus 25% in tandir burns for mortality. The same authors found an amputation rate of 0.3% in non-tandir burns versus 13.3% in tandir burns. Since the tandir is well-shaped, it causes burns mostly on the hands and feet. In parallel to the other tandir studies [2,5], our study also showed that (84.9%) the hand and foot regions were most affected (Table 1). In tandir burns, the involvement of both hands increases the morbidity. Bekerecioğlu et al. [2] reported that the rate of involvement of both hands was higher than 10%. In our series, bilateral hand burns occurred in 5 (11.1%) of the 40 cases.

FTSGs have been the most commonly used method for burn contracture release in our series (Figure 4). STSG used in our series were limited to the less risky sites for contracture. Our experience to date suggests that the lesser utilization of STSG leads to the less observation of contracture. Although FTSG and STSG are used in relatively less risky areas, such as the palmar region [9,10], we believe that flap surgery should be performed, especially in moving areas such as joint surfaces. This will result in better long-term cosmetic and functional results. Although the surgical procedure of skin grafts is easier, the major disadvantage is that they tend to contract further and require further release [11]. Therefore, in our study, we used the skin graft as a complementary procedure for flap surgery.

For the web space contractures, our choice of flap was the V-M plasty and K-M plasty (Figure 5). It is practical and provides flap coverage of the deep web space. No linear incision remains as a scar. Relapse rates are very low with this technique [12]. Z-plasty techniques have been the backbone of the contracture surgery. It is a simple and effective modality in distal hand contractures. V-Y-Z plasty is a very useful technique to provide sufficient lengthening and to prevent recurrence in the treatment of serious postburn scar contractures. Tan et al. [13] have defined the use of V-Y-Z plasty in treatment of postburn contractures. We effectively use the Z-plasty and V-Y-Z-plasty method in contracture release. V-Y-Z plasty combines the advantages of Z-plasty with the subcutaneous pedicle rhomboid flap [14,15]. We used V-Y-Z plasties in different regions such as finger, palm, axilla and antecubital region (Figure 6).

More severe contractures may need larger flaps. In our series, we have used posterior interosseous artery flap (PIO) and as the first choice in small- to moderate-sized defects of the hand region (Figure 7). Pedicle forearm flaps could be another alternative for the reconstruction of hand contractures [16]. However, sacrifice of a major artery of the hand has been a major drawback. On the other hand, Ulkür et al. [17] have successfully used dorsal ulnar flap for palmar reconstruction with less donor morbidity. We used reverse sural flap on the ankle (Figure 8) and trapezius musculocutaneous pedicle flap on the neck in order to benefit from the advantages of pedicled flaps (Figure 9).

Figure 4. Palmar region and hand fingers postburn contracture release and reconstruction with full thickness skin graft.

Figure 5. Web space postburn contractures release with K-M plasty.

Figure 6. Releases of postburn contractures of hand fingers with V-Y-Z plasty.

Figure 7. Right hand: posterior interosseous artery flap. Left hand: free latissimus dorsi flap.

Figure 8. Release of postburn contracture of ankle with reverse sural flap.

Figure 9. Release of contracture of neck with trapezius musculocutaneous pedicle flap.

Figure 10. Release of postburn contracture of neck with pre-expanded free anterolateral thigh flap.

Figure 11. Release of postburn contracture of neck with free latissimus dorsi flap.

Figure 12. Releases of postburn contracture of palmar region with free latissimus dorsi flap and release of postburn contracture of thumb with multiple Z-plasty.

Free flaps are needed for large contractures that cannot be closed even with pedicled flaps. The choice of flap varies depending upon the patient's needs and the experience of the surgeon. It has been used in the reconstruction of free anterolateral thigh flap (ALT) palmar contractures, a popular option in soft tissue reconstructions [18]. Main critics about ALT flap make a case about the perforator dissection or some variations in its vascular anatomy [19]. Another limitation of the ALT flap is its thickness in the Western populations [20]. We successfully used ALT flap in plantar region in 2 cases, ankle in 1 case and neck in 1 case (Figure 10). Latissimus dorsi (LD) flap is advantageous with its long and large vascular pedicle and low donor morbidity. The flap can be designed obliquely that it is assured that the donor scar lies beneath the bra. LD flap is a safer flap with its relatively less variable anatomy [21]. We have not performed Doppler probe to localize the perforator in any of the cases. Because of these advantages, we preferred free LD flap more frequently as the free flap in our study. We successfully used in palmar region in 3 cases, in dorsum of the hand in 1 case and in the neck region in 2 cases (Figures 7, 11, and 12).

Postburn contracture treatment is never limited to only surgery. For optimal results, postoperative physical therapy should be started as soon as possible [11]. Although tandir has the same pathophysiology as other flame burns, the risk of contracture is very high, because it causes deeper damage and especially affects the extremities. Therefore, it is absolutely necessary to work in coordination with a physiotherapist during the treatment.

Conclusion

Postburn contractures are the most important causes of morbidity caused by burns. Postburn contractures have a devastating effect on quality of life and the ability to perform daily activities. Higher temperatures lead to a deeper tissue damage, and it is more likely to develop a burn contracture. Tissue damage is more severe due to very high temperature of the tandir and as a result, more frequent and heavier burn contracture than other burn etiologies develops, and reconstructive operations are needed more frequently. In addition, because the tandir causes burns mostly on the hands and feet, the possibility of burn contracture increases even more. Especially the raising of the tandir (which can cause permanent physical and psychological problems by affecting children at the beginning of their life) and forming a barrier or completely prohibiting access to it, will prevent the occurrence of irreversible traumas.

Disclosure statement

The authors disclose that any financial and personal relationships with other people or organizations that could inappropriately influence (bias) this work has not been available in this study.

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