

Management of Post Burn Mutilated Hand

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ABSTRACT

This study included 40 cases suffering from post-burn hand deformities admitted to Assiut University Hospital and Luxor International Hospital from June 2004 to May 2006. Their ages ranged between 4 and 45 years with a mean age 24.5 years. (Twenty-two females and eighteen males). They presented by a variety of post-burn hand deformities as the following:

- A- Dorsal hand contracture (14 cases).
- B- Volar contracture (10 cases).
- C- First web space contracture (3 cases).
- D- Post burn syndactyly (2 cases).
- E- Wrist deformity (3 cases).
- F- Skin and tendon affection (2 cases).
- G- Complex deformity (6 cases).

All patients underwent a variety of surgical procedures specific to the individual post-burn hand deformity.

Post operative splintage of the hand for 10 days in cases covered by skin graft to prevent recontracture again. Also postoperative physiotherapy program started at the second week to gain good functional results. The follow-up period ranged from 6-20 months.

The results were satisfactory in most of cases as regard:

- Quality of coverage which was achieved in most of cases except one case which show partial loss of skin graft which healed by secondary intention.
- Full range of motion was achieved in most of cases except that have joint affection.

Conclusion: Based on our results, management of post burn hand deformity depend upon several factors:

Initial treatment of burned hand, it is of great importance for prevention of secondary deformities.

- On secondary burn management the first step is the release of the contracture, which should be complete and include all contracted structures.
- The second step is the proper selection of methods of coverage for resultant defects using either skin grafts or flaps depending on the presence of exposed tendons, nerves or joints.

- Third step is the presence of intensive physiotherapy program immediately after operation to gain a very good function.

INTRODUCTION

The hand is the main interface between man and his environment. It is an organ of perception and expression [1].

Unfortunately hands are the most vulnerable part of the body to be affected from burns injuries. These injuries are very unique and therefore categorized as major injuries by the American Burn association. This categorization emphasizes as a importance of the hand, not only to the burned individual but also to society as a whole [2].

Post-burn hand deformities, unlike other post-burn deformities have a wide variety of presentation. More important is that the deeper structures (other than the skin) can contribute to the contracture. Combinations of deformities can present bizarre presentations, especially when there is flexion contracture of a joint and extension contracture of the next joint [3].

Management of post-burn hand deformities can be a lengthy and complicated procedure. Reconstructive surgeon tackling this problem must consider the patient's social and occupational needs as well as consideration of other post-burn deformities in the body and the patient's psychological and motivational status [4].

PATIENTS AND METHODS

This study included 40 cases suffering from post-burn hand deformities, admitted to Assiut University Hospital and Luxor International Hospital from June 2004 to May 2006. Their ages ranged between 4 and 45 years with a mean age 24.5 years. (Twenty-two females and eighteen

males). They presented by a variety of post-burn hand deformities such as: Skin contractures in the form of: Dorsal contractures, volar contractures, web syndactyly, first web contractures and wrist contractures-skin and tendon deformities-complex deformities. (Skin, tendons and joint deformities) the deformities were either within normal range of motion (ROM) or outside normal range of motion (ROM).

Patient's evaluation:

This includes complete history of the accident nature and the primary burn management and its duration.

Evaluation of the hand functions: The patient was asked to specify the impairment caused by the deformity.

Local examination of the hand includes:

- A general appearance of the hand and its position in rest.
- Direct observation of the hand activities using Jebsen's test.
- Skin examination.
- Joint movement's.
- Tendon examination.
- Vascular examination.
- Clinical nerve examination.

Investigations: Was according to the severity of the condition and the surgical procedure done as (Plain X-ray, MRI and Doppler Ultra Sound).

Surgical procedures:

All patients underwent a variety of surgical procedures specific to the management of the individual post-burn hand deformity (Table 1). When the deformity presented bilaterally, the hand, most affected, was operated on first, regardless of hand dominance.

The anesthesia was in several forms: Local intravenous in 16 patients; brachial plexus block in 8 patients and general anesthesia in 16 patients. And all cases used a tourniquet.

Postoperative care: All patients received the following:

- 1- Broad spectrum antibiotic according to their body weight for 7 days postoperatively.
- 2- A strong anti-inflammatory for 5 days post-operative.

3- Elevation of the hand to prevent postoperative edema and to alleviate the pain.

4- A light bandage and monitoring of hand vascularity in the first 48 hours in form examination of color, temperature and capillary refilling of the fingers and hand as whole.

Post operative hand splint was done usually especially in cases requiring skin graft to prevent recontracture and also postoperative edema in ideal position (30° wrist extension, 90° M.P. joint flexion, extension of P.I.P. joint, I.P. joint and D.I.P. joint) for 8-10 days.

Physiotherapy program was planned for every case according to the surgical procedure done in the form of:

- Passive and active exercises of the fingers which started from the second week postoperatively to obtain good range of motion.
- Ultrasound wave applied for several sitting to relax the burn scar.
- Pressure garment and anti-scar cream were applied from the third week postoperatively for 6 months to prevent the development of the hypertrophic scar.
- In cases which was accompanied by tendon repair, the splint age remain for 6 weeks with controlled exercise to the affected finger to prevent development of tendon adhesion then the patient underwent extensive physiotherapy program.

Follow-up period ranged from 6 months to 20 months.

RESULTS

Analysis of patients showed predominance of the female as regard to sex and as regard age the majority of patients were under age 30 years old. The predominance of fire as initial injury. The majority of deformities were skin contractures (dorsal contractures, volar contractures, syndactyly and first web and thumb deformities) with predominance of the dorsal contracture (46.33%). As regard fingers contractures predominance of little finger contracture (70%). Hands were affected in 8 cases, the right hand in 15 cases and the left one in 17 cases.

Dorsal contracture was present in 14 cases and treated by release and covered by split thickness skin graft, distally based radial forearm flap and groin flap (Table 2).

Volar contracture was present in 10 cases, required after the release of fingers either split thickness graft and splint or multiple v-y plasty (Table 4).

There are two cases presented by burn syndactyl treated by release and multiple v-y plasty with very good results (Table 6).

There are three cases presented by varying degrees of first web contracture treated either by multiple 5 flap technique or distally based radial forearm flap (Table 7).

There are 3 cases treated from wrist contracture after release either by split thickness skin graft, or multiple y-v plasty or pedicle groin flap (Table 8).

There were two cases with tendon affection treated either by tenolysis or tendon graft (Table 10).

There are 6 cases presented by varying degrees of complex deformities that needs different attack of both joint and tendon in addition to skin problem (Table 11).

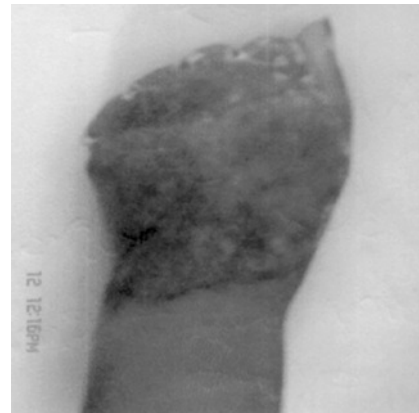
Case (1): P.B. dorsal contracture treated by release and split thickness skin graft.



Case (1-A): Preop. Dorsal contracture.



Case (1-B): Post-op. in extension with complete graft take.



Case (1-C): Good flexion post-op. with split thickness graft.

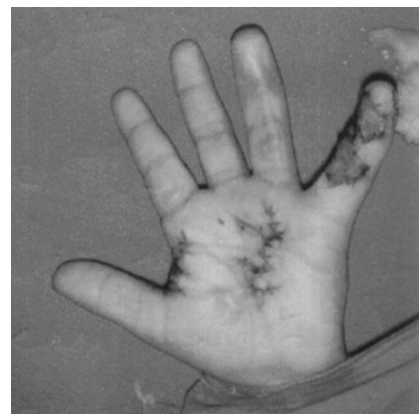
Case (2): Volar contracture treated by multiple v-y plasty.



Case (2-A): Pre-op. P.B. volar contracture over the fingers.



Case (2-B): Intraop-plan of multiple v-y plasty releasing finger contracture.

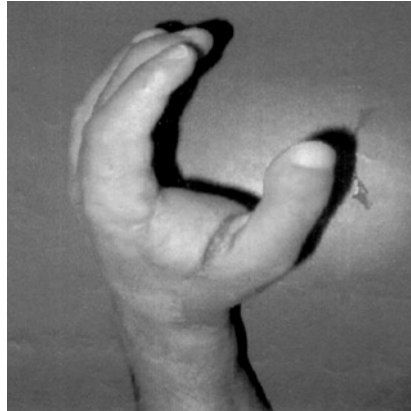


Case (2-C): Post-op. view after release of contracture and covering by multiple v-y plasty and split thickness skin graft.

Case (3): First web space release using radial forearm flap.



Case (3-A): Pre-op. show narrow first web space.

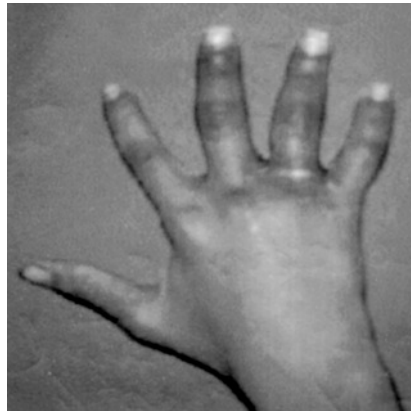


Case (3-B): Post-op. showing release and radial forearm flap.

Case (4): Syndactyl treated by multiple v-y plasty.



Case (4-A): P.B. syndactyl of fingers.



Case (4-B): Post-op. after release and use multiple v-y plasty.

Case (5): Post burn contracture wrist.



Case (5-A): Pre-op. wrist contracture.



Case (5-B): Intra-op. release of burn scar.

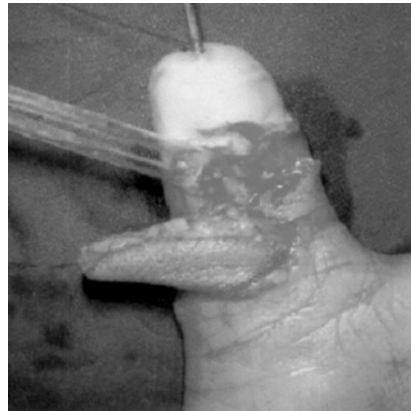


Case (5-C): Post-op. good coverage and restoration of function by split thickness skin graft.

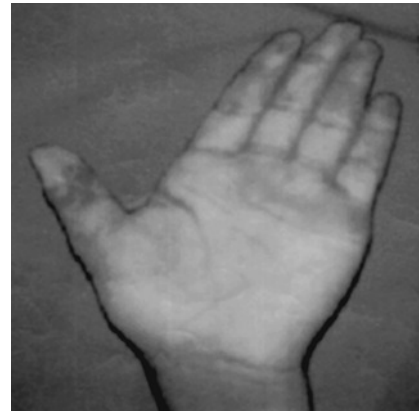
Case (6): Complex deformity in distal phalanges of thumb.



Case (6-A): Pre-op. deformed thumb.



Case (6-B): Plan, elevation and tunneling of the first dorsal metacarpal flap.



Case (6-C): Late post-op. with good coverage and restoration of function.

Table (1): Different surgical modalities.

Dorsal contracture 14 cases	9 cases covered by split thickness skin graft 2 cases covered by distally based radial forearm flap 3 cases covered by pedicle groin flap
Volar contracture 10 cases	7 cases underwent release and split thickness graft 3 cases treated by multiple v-y plasty
First web space reconstruction (3 cases)	2 cases treated by multiple 5 flap plasty 1 treated by distally based radial forearm flap
Syndactly of fingers (2 cases)	Was treated by release and multiple v-y flap and split thickness graft.
Wrist reconstruction (3 cases)	One case underwent release and covered by v-y plasty One case underwent release and split thickness graft and splint One case underwent release and groin pedicle flap
Tendon reconstruction (2 cases)	One case underwent tenolysis The other one underwent tendon transfer
Complex deformities (6 cases)	3 cases treated by release, tenolysis, capsulotomy and skin graft 1 case treated by release and cross finger flap 1 case treated by release, tenolysis, capsulotomy and direct closure 1 case treated by release, capsulotomy, distally based first dorsal intermetacarpal flap

Table (2): Results of reconstruction for dorsal contractures.

Case	Reconstruction	Result	Secondary procedures
9 (16 hands)	Split thickness skin graft	Take 98%	Flexion contracture of little fingers (one case)
2	Distally based radial forearm flap	Complete survival	
2	Island groin flap	Complete survival	
1	Pedicled groin flap	Complete survival	

Table (3): Functional gain after dorsal contractures reconstruction.

Preoperative position of deformity		Postoperative gain	
Within normal ROM	Outside normal ROM	Limited ROM	Full ROM
10 patients	4 patients	2 patients	12 patients

Table (4): Results of reconstruction of volar contractures.

No.	Reconstruction	Results
8 fingers	X-release S.S.G	Local flaps completely survived and complete take of the S.S.G.
9 fingers	Release and S.G. 5 full thickness 4 prepuce skin	Complete take
7 fingers	Multiple Y-V plasty	Local flaps completely survived

Table (5): Functional gain after volar contractures reconstruction.

Preoperative position of deformity	Limited ROM	Full ROM
All cases flexions within normal ROM		24 fingers

Table (6): Results of reconstruction of syndactyly.

No.	Reconstruction	Results
6 webs space	Three square flaps and S.S.G.	Complete survival of the flaps and graft take 100%
4 webs space	V-M plasty	Complete survival of the flaps

Table (7): Results of reconstruction of the first web contractures.

No. of cases	Reconstruction	Results
2	Five-flap plasty	Complete survival
1	Distally based radial forearm flap	Complete survival

Table (8): Results of reconstruction wrist deformities.

No. of cases	Reconstruction	Results
1 case (2 hands)	Multiple Y-V plasty	Complete survival
1	Split thickness skin graft	Take 100%
1	Pedicle groin flap	Complete survival

Table (9): Functional gain after wrist reconstruction.

Preoperative position of deformity	Limited ROM	Full ROM
Abduction (2 hands)		Full
Abduction		Full
Flexion	Need further reconstruction for tendons and nerve	

Table (10): Results of reconstruction for tendon deformities.

Case	Reconstruction	Results
1	Tendon transfer	Good opponens
1	Tendon graft	100% take

Table (11): Results of reconstruction for complex deformities.

No. of cases	Reconstruction	Results
3 cases (8 fingers)	X-release, tenolysis, capsulotomy and skin graft	Complete survival and take
1 case	Release and cross finger flap	Complete survival of the flap
1 case (1 thumb)	X-release, tenolysis, capsulotomy and distally based first dorsal intermetacarpal flap	Partial superficial desquamation of the flap (Healed conservative)
1 case (4 fingers)	Tenolysis, capsulotomy and direct closure of the grafted skin	Complete survival and take

Table (12): Functional gain after complex deformities reconstruction.

Preoperative position of deformity	Limited ROM	Full ROM
Flexion in 5 cases within normal ROM (10 fingers)	4	1
Extension in 1 case outside normal ROM (4 fingers)	2 fingers (little and ring)	2 fingers (middle and index)

DISCUSSION

The complexity of the post-burn deformity lies in the fact that several structures may contribute to the deformity, skin contracture, joint stiffness or tendon adhesions. Thus, pre-operative evaluation of post-burn deformed hand is very important. Unfortunately, this is a difficult task, frequency it forces the surgeon to resort to special investigations or to wait for the intra-operative assessment to define the problem [5].

In this study, dorsal contracture treated by split thickness skin graft in 9 patients, a thick split thickness skin graft was used as coverage; excellent results were achieved in those patients. In this study no graft was lost totally; partial loss was recorded in only one case secondary to infections. The present results are consistent with previous reports [6], managing contractures of the dorsum of the hand by using skin graft as coverage. In comparison to which is better split thickness or full thickness skin grafts. We agree with others studies [7] that using the thick split thickness skin graft has been proposed as practical compromise.

In this study the hand immobilized in the fist position for 8-10 days after skin grafting, where the greatest amount of skin can be grafted in a fist position to avoid secondary contractures by graft contraction, also no joint stiffness was recorded in this period. This maneuver is consistent with others [8] who analyzed the length of the dorsal hand surface in the hand positions, where the total length in a fist position was significantly increased in comparison with anatomic and safe positions. The prolonged periods of the postoperative physiotherapy, splitting and pressure garments are required to maximize aesthetic and functional outcome.

In one case radial forearm flap used as coverage, achieved a satisfactory result. The radial forearm flap has many advantages, resulting in its excellent reputation. As stated previously, it is a reliable flap, with a robust arterial inflow through retrograde flow into the radial artery, good venous drainage through the venae comitantes of the radial artery. It gives skin that is thin, pliable and hairless. Also a large skin territory to be included in the flap. Our results were consistent with [9,10,11].

In 3 cases, groin flaps were used as soft tissue coverage, the groin flap has for a long time has been the preferred option in coverage of hand defects. Very long flaps can be designed far beyond the territory supplied by the well-identified artery. Also there were no complications observed with the flaps and good results were achieved.

The drawbacks of this flap, it is thick and need prolonged immobilization till separation. Our results were consistent with [12], who did groin flap for coverage of 65 cases of post burn deformed dorsum of the hand.

In this study we observed that good functional results regained when positions of deformities of the M.P. joints are within the normal ROM and

less functional gain when positions of deformity of M.P. joints are outside the normal ROM.

As regards release of volar contracture, there are several options for covering these palmar finger defects proved to be reliable. The x-release is done across the line of contracture and the edges are sutured bringing soft tissues from the lateral sides and skin graft to maximize the benefit to using the local tissue release [13]. Y-V advancement or V-advancement with Z-plasty as combination, improve the release of linear flexion contractures of the fingers, including thumbs [14].

The results of this thesis were consistent with the previous reports [15,16] for managing palmar contractures by using skin graft and local flaps as coverage. Also we agree with Pensler et al. [17] that there is no significant difference between the split thickness and full thickness skin grafts and they claim that the split thickness skin graft has fewer tendencies toward hyper-pigmentation, resulting in superior cosmeses. Also, in our thesis the management of palmar contractures provide functional gain better than the cosmetic result, because positions of deformity usually within the normal range of motion (ROM), however in cases with partial amputation of the fingers, the uses of the finger prosthesis for some missing or lost phalanges or fingers improve the appearance of the burnt hand.

Surgery in the post-burn syndactyly, seeks to accomplish one of three goals: Break line and add length to a straight-line contracture; recreate the web space commissure by use of local flap and add skin from outside the local area for severely scarred web spaces. Multiples local flaps were used for corrections syndactyly depending on availability of unscarred skin [18]. Z-plasty V-M plasty, square flap, five flap release and a dorsal flap with lateral digital extensions are very helpful methods for management of post burn syndactyly [19,20,21].

In our thesis, all cases of post burn syndactyly were managed by using multiple square flap the results were excellent and prove the reliability and feasibility of using local flaps in web contractures with long-term success. This is consistent with the work of Oren & Amiram [22] who used multiple square flap for management of 33 post burn syndactyly.

First web adduction contractures (3 cases):

Local flaps are the best option if available; they are thin, of similar color, texture match and do not mutilate other body regions [23,24].

In this study, 2 cases were treated by skin release with partial release of the adductor pollicis and first dorsal interossei and reconstructed by use of five-flap Z-plasty, satisfactory results were achieved in those patients.

In the other one, skin release was done, with partial release of the adductor pollicis and resultant defect was covered by distally based radial forearm flap with good and ample coverage and this is consistent with [25,26].

Wrist deformity (3 cases):

The first one has bilateral abduction deformity, been managed by multiple Y-V plasty extending from dorsum of the thumb to the elbow. The other hand, four months later, was corrected by same technique.

The second case, with dorsal and abduction contractures of the wrist and thumb, was managed by complete excision of the scar tissues and the resultant defect was covered by skin graft. Splinting of the hand and wrist for 10 days till complete take of graft, followed by early physiotherapy.

The third case, with flexion contractures of the wrist; release of the contractures and the defects were covered by groin flap, for further reconstruction of the flexor tendons and median nerve in the wrist. Satisfactory results were achieved in all cases.

Skin and tendon deformities (2 cases):

The first case had lost extensor of the left thumb, managed by tendon transfer, from flexor digitorum superficialis of the ring finger for oppono-plasty.

The second case with post-burn loss of the medial three-extensor tendons on the dorsum of the left hand, was managed by tendons grafts.

Postoperative splintage of the hand was done in both cases in position of ease for 6 weeks allowing only controlled movement of the fingers to prevent tendon adhesion, followed by extensive physiotherapy program. Excellent results were achieved in all cases of tendon reconstruction in this thesis.

Our plan in primary covering the burn wound was providing flap cover for further reconstruction the underlining tendon pathology and in the second stage, tendon reconstruction was done.

We did not agree with others [27,28], who did coverage and tendon transfer as a composite flap in the same sitting for fear of infection.

6 cases of the complex deformities, with skin, tendon and joint deformities, all were managed by release of skin contractures, tenolysis and capsulotomy by partial release of the collateral ligaments. Satisfactory results were achieved in all cases.

In the vast majority of patients the initial thermal injury is limited to the skin alone; the underlying tendons and joints are usually spared. Prolonged wound healing with its attendant oedema, infection, fibrosis and immobilization, can lead to secondary joint contractures, rupture of extensor tendon mechanisms and adhesion of gliding tissues.

In complex deformities where the deep structures such as tendons; ligaments and joints have been affected directly or as a result of improper initial therapy, reacquisition of a full range of motion after reconstruction is not always possible. Also joint subluxation or deviations resulting from imbalance in ligaments and muscular forces our results in the management of complex deformities which were consistent with other studies [29].

Conclusion:

Based on the results of this thesis a plan for management of post-burn hand deformities was proposed.

- The correct initial treatment of hand burns is a matter of great importance for the avoidance of secondary deformities, as it guarantees hand function more surely than reconstruction.
- The first step is the release of contracture, which should be complete and includes all contracted structures.
- The second step is the proper selection of methods of coverage for resultant defects using either skin grafts or flaps depending on the presence of exposed tendons, nerves or joints.
- Third step is the presence of intensive physiotherapy program immediately after operation to gain a very good function.
- In dorsal contractures, the entire scar should be removed and any residual contracture should be released. Usually replacement or resurfacing with skin grafts is satisfactory. Flap coverage may occasionally be necessary if further reconstruction for deep structures such as tendons or joints is planned. Tissue transfer, even with free tissue, is not sufficient to improve hand function as long as tendon and joint problems still exist.
- Good functional results are achieved when the positions of deformity of the hand joints are within the normal ROM and less functional gain

occurs when positions of the deformity of hand joints are outside the normal ROM. So popularization of the arthroplasty by using joint prosthesis in some selected cases may improve the functional gain.

REFERENCES

- 1- Robson M.C., Smith D.J., VenderZee, et al.: Making the burned hand functional. *Clinics in Plast. Surg.*, 19: 663, 1992.
- 2- Nelson D.L.: The importance of the physical examination. *Hand Clin.*, 13: 13-5, 1997.
- 3- Gokalan L., Ozgor F. and Gursu G.: Factors affecting results in thermal hand burns. *Ann. of burns and fire disasters Vol. IX n. 4*, 1996.
- 4- Woo S.H. and Seul J.H.: Optimizing the correction of severe post burn: Hand deformities by using aggressive contracture release and fascio-cutaneous free-tissue transfers. *Plast. Reconstr. Surg.*, 107: 1, 2001.
- 5- Burm S.J. and Oh J.S.: Fist position for skin grafting on the dorsal hand: Clinical use in deep burns and burn scar contractures. *Plast. Reconstr. Surg.*, 105: 531, 2000.
- 6- Iwuagwu F.C., Wilson D. and Bailie F.: The use of skin grafts in post burn contracture release: A 10 years review. *Plast. Reconstr. Surg.*, 103: 1198, 1999.
- 7- Mann R., Gibran N.S., Engray L.H., et al.: Prospective trial of the thick Vs standard split-thickness skin grafts in burns of the hand. *J. Burn Care Rehabil*, 22: 390, 2001.
- 8- Burm S.J., Chung H.C. and Oh J.S.: Fist position for skin grafting on the dorsal hand: I. Analysis of length of the dorsal hand surface in hand positions. *Plast. Reconstr. Surg.*, 104: 1350, 1999.
- 9- Al-Qattan M.M. and Ziesmann M.: Immediate de-syndactylization of the reverse radial forearm flap. *J. Hand Surg. Br.*, 25: 61, 2000.
- 10- Rogachefsky R.A., Mendieta C.G., Galpin P., et al.: Reverse radial forearm fascial flap for soft tissue coverage of hand and forearm wounds. *J. Hand Surg. British and European Volume 25*: 358, 2000.
- 11- Adani R., Tarallo L. and Macococcio I.: Island radial artery fascio-tendinous flap for dorsal hand reconstruction. *Ann. Plast. Surg.*, 47: 83, 2001.
- 12- Koshima I., Nanba Y. and Tsutsui T., et al.: Superficial circumflex iliac artery perforator flap for reconstruction of limb defects. *Plast. Reconstr. Surg.*, 113: 233, 2004.
- 13- El-Oteify M.A.: A versatile method for the release of burn scar contractures. *Br. J. Plastic. Surg.*, 34: 326-328, 1981.
- 14- Peker F. and Celebiler O.: Y-V advancement with Z-plasty: An effective combined model for the release of post-burn flexion contractures of the fingers. *Burn Aug.*, 29: 479, 2003.
- 15- Watson S.B. and Miller J.G.: Optimizing skin graft take in children's hand burns the use of silastic foam dressings. *Burns*, 19: 519, 1993.
- 16- Barret J.P., Desai M.H. and Herndon D.N.: The isolated burned palm in children: Epidemiology and long-term squeals. *Plast. Reconstr. Surg.*, 105: 949, 2000.
- 17- Pensler J.M., Steward R., Lewis S.R., et al.: Reconstruction of the burned palm: Full thickness versus split thickness skin graft, long-term follow-up. *Plast. & Reconstr. Surg.*, 81: 46, 1988.
- 18- Chang L.Y., Yang J.K. and Wei F.C.: Reverse dorsometacarpal flap in digits and web-space reconstruction. *Ann. Plast. Surg.*, 33: 281, 1994.
- 19- Pribaz J.J. and Pelham F.R.: Use of previously burned skin in local fascio-cutaneous flaps for upper extremity reconstruction. *Ann. Plast. Surg.*, 33: 272, 1994.
- 20- Hyakusoku H. and Fumiri M.: The square flap methods. *Br. J. Plast. Surg.*, 40: 40, 1987.
- 21- Kojima T., Hayashi H. and Terao Y.: A dorsal flap with lateral digital extensions for palmer web contractures. *Br. J. Plast. Surg.*, 48: 236, 1995.
- 22- Oren L. and Amiram S.: Three-square-flip-flap reconstruction for post burn syndactyly. *British J. Plast. Surg.*, 58: 826, 2005.
- 23- Bhattacharya S., Bhatnagar S.K., Pandey S.D., et al.: Management of burn contractures of the first web space of the hand. *Burns*, 18: 54, 1992.
- 24- Fraulin F.O.G. and Thomson H.G.: First web space deepening: Comparing the four-flap and five flaps Z-plasty. Which gives the most gain? *Plast. Reconstr. Surg.*, 104: 120, 1999.
- 25- Zaki M.S., Rifky M., Makeen K., et al.: Reversed radial forearm flap for reconstruction for the first web of the hand. *Egypt. J. Plast. Reconstr. Surg.*, Vol. 18: 9-14, 1994.
- 26- M., Safak T. and Kecik A.: Coverage of a thumb wound and correction of a first web space contracture using a longitudinally split reverse radial forearm flap. *Ann. Plast. Surg.*, 4: 453, 2001.
- 27- Yajima H., Inada Y. and Shono M., et al.: Radial forearm flap with vascularized tendons for hand reconstruction. *Plast. Reconstr. Surg.*, 98: 328, 1996.
- 28- El-Khatib H.: Tendo-fascial island flap based on distal perforators of the radial artery: Anatomical and clinical approach. *Plast. Reconstr. Surg.*, 113: 545, 2004.
- 29- Graham T.J., Stern P.J. and True M.S.: Classification and treatment of post burn metacarpophalangeal joint extension contractures in children. *J. Hand Surg. Am.*, 15: 450, 1990.