THENAR CRUSH INJURIES

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Crushing of the radial side of the hand results in a wide spectrum of injuries varying from contusion of muscles to total loss. The main problem concerns the function of the thumb. The results of such injuries in 161 hands were reviewed. Those with mild injuries treated conservatively or by debridement alone had good results. When skin flaps were required for wound coverage, the results were still satisfactory. However, when bones and joints were injured, the results were poor. In certain patients opponensplasty through scarred tissue proved to be a good procedure to improve the function of the thumb.

Crush injuries of the hand are common in developing countries where safety measures for machines are still not properly used in factories. Over the past 10 years, we have noticed that the majority of these accidents involve the radial side of the hand with the brunt of the injury sustained by the thenar area (Chow 1979). We have called these "thenar burst injuries" because the muscles literally burst through the skin (Fig. 1). That it mainly involves the radial side is not surprising as this part of the hand is closest to the machine in most manoeuvres. From 1978 to 1984, we saw 161 hands with these injuries (Table I). The patients presented with unique problems involving mainly the function of the thumb. This paper describes the problems and the results of an aggressive method of treatment.

Table I. Incidence of crush injuries at various sites in the hand (1978 to 1984)

Total number of crushed hands	263
Thenar crush	161
Hypothenar crush	68
Whole hand	34

MATERIAL AND METHODS

From January 1978 to December 1984, 161 hands with thenar crush injuries were seen in 160 patients, with the dominant hand involved in most cases (103 dominant : 58 non-dominant). There were 133 men and 27 women

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Table II. The various tissues damaged in 161 thenar crush injuries

80	Skin and muscle
53	+ bone and joint
31	+ nerve
28	+ tendon
21	Total destruction

with ages ranging from 16 to 64 years (average 29 years); follow-up ranged from six months to three and a half years (average 14 months). The majority had injuries to skin and muscle only, but bone, joint, nerve, tendon, or total involvement could occur (Table II).

Before 1978, the principles of treatment were debridement and reconstruction, either immediate or

Fig. 1

Muscle bursting out.

Fig. 2

Fig. 4

Figure 2 – Fixation with miniplates. Figure 3 – Coverage with an abdominal flap. Figure 4 – K-wire to keep first web space open.

Fig. 3

late. During debridement, however, a rather conservative approach was adopted: if in doubt, the tissue was left and the decision on radical debridement was postponed until there was a more definite demarcation (Boyes 1970; Rank et al. 1973; Milford 1980). However, definite gangrene in such cases did not occur until two to three weeks later; we now believe that this was the main reason for bad results, due to progressive necrosis, infection, and eventual scarring of the thumb, sometimes

involving the fingers as well. Since January 1978, therefore, we have adopted a radical approach: if in doubt concerning viability, the tissue is excised radically. This, of course, sometimes leaves a large skin defect, exposed bones, exposed tendons, or even doubtfully viable thumbs, and must be combined with techniques such as immediate flap cover, fixation of bone, and microvascular procedures. In summary, our treatment for such cases consists of:

1. Radical debridement of muscle, subcutaneous tissue and skin.
2. Rigid bone fixation with a K-wire and a miniplate (Fig. 2).
3. Immediate skin cover, mostly by groin flaps or lower abdominal flaps (Fig. 3).
4. Maintenance of the first web space with a K-wire (Fig. 4)
5. Vigorous postoperative mobilisation.
6. Late reconstruction.

The early treatment and the later reconstruction carried out on these 161 hands are shown in Table III. **Assessment of results.** Since the major problem is scarring on the radial side of the hand and stiffness of injured bones and joints, the assessment of the range of

Table III. Treatment and reconstruction of the 161 hands

<i>Early acute treatment</i>		<i>Late reconstruction</i>	
Conservative	27	Release + flap	16
Debridement	32	Nerve graft	4
Skin flap	35	Tenolysis	3
Bone fixation	32	Interphalangeal fusion	4
Nerve repair	28	Opponensplasty	31
Tendon repair	4	Toe-to-hand	4
Revascularisation	4		
Amputation	25		

opposition of the thumb is the major consideration in the analysis of results. Opposition was measured by the method of the International Federation of Societies for Surgery of the Hand (IFSSH) (Swanson 1973). However, this assessment on its own is inadequate as many thumbs have had extensive removal of muscles, leaving a weakened pulp-to-pulp opposition pinch (Fig. 5). Therefore, a combined method as proposed in Table IV is used for assessment.

RESULTS

Conservative treatment. Twenty-seven patients were treated conservatively by a boxing-glove dressing (James 1960) and elevation until the swelling subsided, usually in four to six days' time. They were then started on vigorous mobilisation. These hands had sustained either no lacerations at all or insignificant skin damage, and pain could be easily controlled by simple analgesics. Excessive pain signified either a compartment syndrome, extensive necrosis, or a haematoma (Bunnell, Doherty and Curtis 1948), and required exploration and debridement. The results in these 27 patients are shown in Table V. As can be seen, despite the relatively mild damage, more than half of them had lost adequate opposition power to the middle and ulnar fingers.

Radical debridement. Thirty-two patients were explored and dead tissue removed; in these patients no additional procedures were necessary. The skin wounds were sutured, and the hands put in boxing-glove dressings and kept elevated for a few days until swelling subsided. Vigorous physiotherapy and occupational therapy then

Fig. 5

Radical debridement leading to a flail thumb.

followed. The results are shown in Table V; surprisingly, they were not much worse than those of the conservative group although the severity of injury was greater.

With skin flaps. In 35 patients, after radical debridement, it was decided to replace lost skin by flaps, either from the lower abdomen or the groin (McGregor and Jackson 1972). The first web space frequently required K-wire insertion to keep it open. Fingers, wrist, elbow, and shoulder movements were encouraged at an early stage. The pedicle of the skin flap was detached at about three weeks after insertion and the K-wire was removed at the same time. Vigorous mobilisation of the hand was carried out. The results were only slightly inferior to the debridement group. Although very few of these patients could adequately oppose the thumb to the two ulnar fingers, the majority could still maintain strong opposition to the index and middle fingers (Table V).

With reduction and fixation. When bones and joints were involved, the fractures and dislocations were reduced and fixed with K-wires or miniplates. Another K-wire kept the first web space open (Fig. 4) and this was removed after three weeks for gentle mobilisation. When the fractures were healed at about 8 to 12 weeks, vigorous

Table IV. Grading of results

Grade 1:	Able to touch little finger with >50% strength
Grade 2:	Able to touch ring finger with >50% strength
Grade 3:	Able to touch middle finger with >50% strength
Grade 4:	Able to touch index finger with >50% strength
Grade 5:	Unable to touch index finger

Table V. Comparison of results obtained from different forms of treatment

Grade	Conservative treatment	Debridement only	Debridement plus		
			Skin flaps	Fixation	Opponensplasty
1	6 22	6 19	1 3	0 0	0 0
2	6 22	5 15	3 9	2 7	7 24
3	5 19	7 22	14 40	9 28	13 40
4	6 22	5 15	15 43	20 62	11 36
5	4 15	9 29	2 6	1 3	0 0

Italic figures are percentages

Fig. 6

Opponensplasty through a skin flap.

mobilisation was begun. However, the majority of these 32 patients could only oppose to the index finger with adequate strength (Table V).

With opponensplasty. In 31 patients, there was weakness of abduction and opposition after the initial treatment because of the radical debridement of the thenar muscles. In fact, none of them was able to oppose to the middle finger with enough strength, although passively the opposition was better. In such patients it was decided to carry out an opponensplasty between 6 and 16 months after injury, using the flexor digitorum sublimis of the ring finger (Bunnell 1938) in most cases, but sometimes the extensor indicis (Burkhalter, Christensen and Brown 1973). The tendon transfer had to be tunnelled through scarred tissue or skin flaps (Fig. 6). However, the results were good: when assessed six months later, most of the patients had improved their opposition by one or two grades (Table V).

DISCUSSION

Crush injuries of the hand pose two main questions.

When is conservative treatment indicated? In our conservatively treated group, two criteria were the prerequisites: (1) insignificant skin damage, and (2) pain controlled by simple analgesics. The results of conservative treatment seemed to be the same as in the debridement group, although the latter had more severe injuries. When there is definite skin loss, nerve division, tendon rupture, divided arteries, or unstable fractures and dislocations,

surgery is indicated. In the less severely injured cases, it may be difficult to decide. The important point is whether we can afford to leave doubtfully viable tissue, or whether we should excise it and reconstruct the hand immediately. It is also important that a compartment syndrome of the muscles of the hand should be sought and detected early. For these reasons it is better, if there is any doubt, to explore and perform a radical debridement.

Wait or excise immediately? This second question arises during debridement. If the crushed tissue is of doubtful viability, should we leave it for a few days and wait for better "demarcation", or should we excise it and perform primary reconstruction immediately? This is especially important for the skin, which is so vital in the hand. Many surgeons wait but it has been our bitter experience that "demarcation" may take one to two weeks to become established, during which time the opportunity for early mobilisation and rehabilitation was lost. In fact, the semi-viable tissue continued to cause swelling, pain and stiffness, and invited fibrosis. We have, therefore, adopted a radical approach of "debridement if in doubt". This, of course, must be coupled with surgical skills and procedures such as emergency skin flaps, fixation of fractures, and microsurgery to nerves and vessels.

Our results have justified this approach. The results of the debridement group and the skin flap group, compared well with those of the conservative group, although the latter had less severe injuries. With bone

Fig. 7

"Frozen" thumb with atrophy and doubtful viability.

and joint involvement, however, the results were significantly worse as these were very severely injured cases and the fractures were frequently so comminuted that fixation was not stable enough for mobilisation.

After the initial treatment, we encountered certain patients who had a relatively good range of passive opposition of the thumb and yet their active opposition was weak. This was due to the policy of radical debridement we had adopted: with radical debridement, we were able to prevent pain, swelling, fibrosis and stiffness, but we might sometimes have excised too much and ended up with extensive loss of the thenar musculature. Adduction, extension and flexion of the thumb was still possible using the long extensors and long flexors, but abduction and opposition was weak. In such cases we have shown that opponensplasty, using the flexor sublimis to the ring finger or the extensor indicis, greatly improves opposition power, giving final results which are comparable to those in the simple debridement group. We therefore have no regrets concerning "over-debridement" of the thenar muscles, as we know that if opposition is weak an opponensplasty will improve the situation. Whereas, if an incomplete

debridement is performed, we can almost predict that the result will be a scarred and "frozen" thumb (Fig. 7).

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