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Original article

High-pressure injection injuries of the fingers: Long-term follow-up in patients after extensive debridement



Lésions des doigts par injection à haute pression: suivi à long terme chez les patients après un débridement étendu

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ABSTRACT

High-pressure injection injuries to the fingers resulting from the introduction of a foreign substance, such as oil or paint, through a minor puncture wound are rare but can have serious clinical consequences. The objective of this article was to examine the long-term outcomes after surgical debridement of these injuries. We present a retrospective case series of 8 adults who had a high-pressure injection injury to their hand and underwent surgical debridement in our facility. Data were extracted from our outpatient registry. Assessment included a full physical examination, grip strength, range of motion, two-point discrimination and Quick Disability of the Arm, Shoulder, and Hand (QuickDASH) questionnaire. We followed 8 male patients for an average of 12.7 years. Their average age was 37 at time of injury and all had injured their right dominant hand. Seventy-five percent of the injuries were to the index finger. Seven out of the 8 patients returned to their pre-injury occupation, 4 out of 8 patients had reduced range of motion of the affected digit. Injury sequelae adversely affected activities of daily living (ADL) with an average QuickDASH score of 26. Grip strength in the injured hand was reduced by an average of 35% in 6 out of 8 patients compared with the uninjured hand. Sensation was also reduced in the affected digit in 7 out of 8 patients. All patients suffered from some level of neuropathic pain and/or cold intolerance. High pressure injection injury to the fingers is a serious event found amongst industrial laborers. In most patients, this injury will lead to long-term disability along with a negative impact on ADL. However, most patients eventually return to their pre-injury occupation. Extensive, single or repeat debridement of high-pressure injection injuries remains a valid treatment option with good long-term results.

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R É S U M É

Les blessures des doigts par injection à haute pression résultant de l'introduction d'une substance étrangère, comme l'huile ou la peinture, par une blessure mineure par perforation sont rares, mais peuvent avoir de graves conséquences cliniques. L'objectif de cet article était d'évaluer les conséquences à long terme du débridement opératoire sur ces lésions. Nous présentons une série rétrospective de 8 individus qui présentaient une blessure à haute pression à leur main droite et qui ont subi un débridement formalisé dans notre institution. Les données ont été extraites de notre registre des patients ambulatoires. L'évaluation comprenait un examen physique complet, la mesure de la force de poigne, des amplitudes articulaires, un test de la discrimination des deux points et un questionnaire, le Quick Disability of the Arm, Shoulder, and Hand (QuickDASH) score. Nous avons suivi 8 patients masculins pendant une moyenne de 12,7 ans. Leur âge moyen était de 37 ans au moment de leur blessure et tous s'étaient blessés à la main droite dominante. Soixante-quinze pour cent des blessures intéressaient l'index. Sept des 8 patients étaient retournés à la profession ayant précédé la blessure, 4 sur 8 patients ont

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souffert d'une diminution de mobilité. Les séquelles de ces blessures ont nui aux activités de la vie quotidienne (AVQ) avec un score QuickDASH moyen de 26. La force de poigne de la main blessée était réduite en moyenne de 35 pour cent chez 6 des 8 patients en comparaison avec la main non blessée. La sensibilité du doigt blessé était également réduite chez 7 des 8 patients. Tous les patients souffraient d'un certain degré de douleur neuropathique et/ou d'intolérance au froid. Les lésions des doigts par injection à haute pression sont un événement sérieux trouvé chez les ouvriers de l'industrie. Chez la plupart des patients, cette blessure entraîne une invalidité à long terme ainsi qu'un impact négatif sur les AVQ. Cependant, la plupart des patients finissent par retourner à la profession occupée avant la blessure. Le débridement étendu, simple ou répété, des lésions par injection à haute pression demeure une option valide de traitement avec de bons résultats à long terme.

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1. Introduction

High-pressure injection injuries occur when a foreign material, such as paint or grease, is inadvertently injected into the fingers. These injuries are uncommon but comprise an occupational hazard for operators of mechanical equipment, such as diesel pumps, paint guns, and high-pressure cleaning equipment [1,2].

The injection ensues at approximately 7000 PSI and is characterized by a small entry wound that initially does not appear to have major clinical significance (Fig. 1). The injury is more common in the index finger of the non-dominant hand [2] and its course is determined by the type of substance injected, injection pressure, and time from injury until debridement [1,3]. Several factors make this a severe injury. First, a mechanical injury occurs because of the injection pressure into a non-dilating cavity, such as a finger or hand. Second, there is chemical damage from the injected material, such as paint or diesel fuel. As a result, injury to the blood supply and necrosis begins. High pressure

injection injuries have a high potential for complications, even with proper treatment. The chance of amputation of the involved finger is up to 50% [1,4,5], which often causes a delay in diagnosis and treatment [1–3,5,6].

The conventional treatment option is urgent surgical debridement and thorough wound irrigation (Fig. 2). After the operation, the wound remains open to allow drainage of the injected material from the deep tissues and healing by secondary intention (Fig. 3). These treatment guidelines are based on a limited number of studies with a small number of participants [3–5,7–12].

The recovery time after these injuries is particularly long and can take years. The wound is not closed during the healing process and many complications are possible, such as neuropathic pain, cold intolerance, stiffness, restriction in range of motion (ROM), and infection [2,4]. The negative effect of long-term treatment on occupational status, mental health, and well-being cannot be ignored [1,2,5].

Considering the above, there is a need for a long-term monitoring of these injuries to justify the aggressive treatment currently indicated by the literature. The objective of this study was to examine the long-term effect of surgical debridement on high pressure injuries to the fingers.

2. Patients and methods

This was a retrospective study comparing clinical outcomes after a high-pressure injection injury. The study was approved by our local IRB. All patients were treated at our facility between 1990 and 2019. We queried our hospital outpatient registry and collected data from all patients who underwent formal debridement for a high-pressure injury to their fingers. Inclusion criteria was an injury to the finger with paint or diesel. Exclusion criteria were comorbidities, such as diabetes, a connective tissue disorder (Raynaud, scleroderma), or peripheral vascular disease at the time of injury and individuals less than 18 years of age. We investigated the following parameters: affected side and finger, dominant hand, type of substance injected (water/oil-based paint or grease), time from injury to surgery, number of total surgical procedures, medical leave duration, and change in occupation. A Quick Disability of the Arm, Shoulder, and Hand (QuickDASH) score was calculated. A score below 10 is considered normal with a good functional outcome, a score above 10 represents an abnormal outcome and a score of 100 is the worst possible scenario [13].

During their last follow-up visit, each patient grip strength of injured hand was tested and compared to the uninjured hand using a calibrated Jamar dynamometer. An average of three measurements were performed on the injured hand and compared to the uninjured hand. Tactile sensation was evaluated using a two-point discrimination test. The value for a normal finger is < 8 mm [14]. We also incorporated the Semmes–Weinstein monofilament test in which tactile sensation of the 2.83 monofilament or smaller



Fig. 1. Finger with grease injection injury.

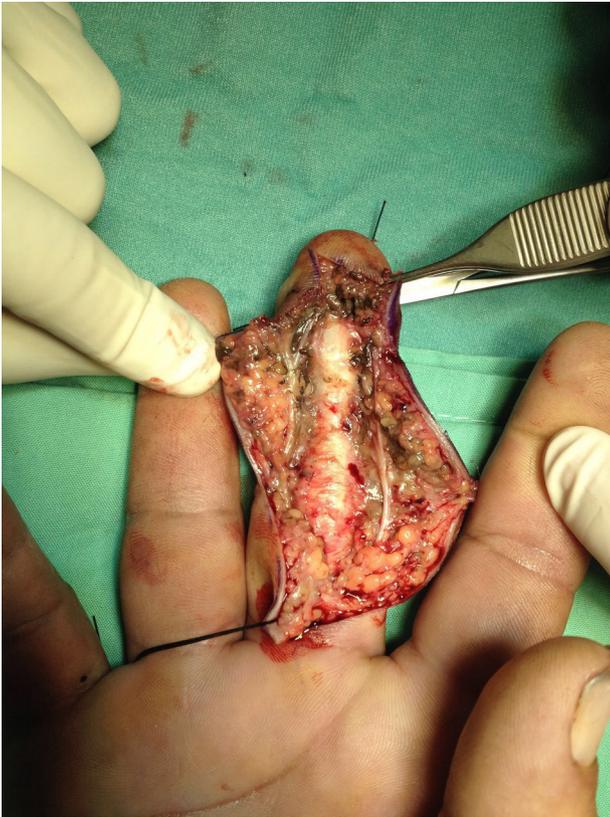


Fig. 2. Finger after incision and debridement.

is considered normal [15]. ROM in the metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints was evaluated with a standardized external gauge. A literature review of relevant published case series was done (Table 1) [3,5,6,11,16–22].

3. Results

We followed 8 patients for an average of 12.7 years (range: 1–18 years). The patients were all male and the average age at the time of accident was 37 years (range: 27–47 years old). All injuries were to the patient's right dominant hand. Seventy-five percent had injured the volar aspect of the index finger. Grease was injected into 4 fingers and paint into the other 4 (2 oil-based paint and 2 water-based paint) (Tables 2–3). The average time from injury to the first surgical debridement was 5.9 hours (range: 20 minutes to 11 hours). Seventy-five percent of patients had repeated debridement with an average of 2.5 surgical procedures per patient (range: 1–5).

Fifty percent of the patients suffered from reduced ROM of the affected finger. One patient had PIP joint involvement with a flexion contracture (90–120 degrees), two patients had a DIP joint flexion contracture (20–60 and 0–45 degrees), which prevented them from making a full fist and reduced their grip strength. No patient had reduced ROM of the MCP joint. Sensation was affected in 7 out of 8 patients with a reduction in both the two-point tactile discrimination and Semmens–Weinstein monofilament testing (Table 2). All patients suffered from some level of neuropathic pain and cold intolerance. Grip strength was reduced in 6 out of 8 individuals with an average 35% reduction in the injured hand compared to the unaffected hand.

Activities of daily living (ADL) were altered as a result of the injury in 6 patients out of 8, with an average QuickDASH score of 26 (range: 2.5–68). Seven out of the 8 patients returned to their



Fig. 3. Finger after closure by second intention.

pre-injury occupation and the average time off work was 11 months (range: 1 week to 30 months).

4. Discussion

We evaluated 8 patients who had a high-pressure injection injury and underwent extensive debridement in the operating room with an average follow-up of 12.7 years. Although the number of participants in this study was small relative to other studies [3,5,13], to our knowledge, the follow-up period is the longest to date. A second major strength of our study is the extensive assessment of the patients at their final follow-up visit, including a full detailed physical exam and a QuickDASH questionnaire of ADLs.

We did not include high pressure water injuries. Firstly, we did not encounter such injuries in our data collection. Secondly, we feel these are different clinical entities, with good outcomes after conservative treatment [23].

Consistent with studies performed by Becler et al. and Obert et al. [16,24], better outcomes were found when the high-pressure injury was caused by water-based paint compared to grease and oil-based paint. In our study, two patients with injuries caused by water-based paint had a full recovery in terms of ROM, sensation,

Table 1
Published case series of high-pressure injection injuries of the fingers.

Year	Authors	No. of patients	Injected substance	Mean follow-up (years)	Remarks
1937	Rees [22]	1	Diesel oil	< 1	First case-report described
1967	Stark et al. [6]	14	Paint	< 1	Time until proper treatment was a major factor in the outcome
1968	Kaufman [19]	14	Paint, diesel fuel, oil and automotive grease.	< 1	Paint was the most irritant substance
1975	Gelberman et al. [18]	26	Paint and grease	< 1	Grease injection is less toxic than paint
1985	Thakore [11]	4	Epoxy paint gun	< 1	
1991	Pai et al. [20]	8	Paint, and one each from grease, water, benzene, and hydraulic oil	4	
1993	Pinto et al. [3]	25	Oil, grease and solvents	1	Proposed aggressive debridement
2005	Wieder et al. [5]	23	Oil, grease and solvents	8.5	
2005	Wong TC et al. [22]	28	Automotive grease, diesel oil and paint	1	Conservative treatment for minor injuries
2007	Bekler H et al. [16]	14	Paint, automotive grease, solvents and diesel oil	2	Described the mechanism of soft tissue damage
2011	Chen et al. [17]	14	Oil, grease and solvents	1	Applied vacuum sealing drainage technique

Table 2
Outcome data.

Patient	Follow up (years)	Time until debridement (hours)	Total number of procedures	Return to work (Months)	Change of occupation	TAM MCP	TAM PIP	TAM DIP	2PD RDN	2PD UDN	MF UDN	MF RDN	Grip strength reduction ^a	QuickDASH
1	13	11	1	0.2	No	Full	Full	Full	8	8	4.31	4.31	0%	2.5
2	13	5	2	24	No	Full	Full	0-45	14	NM	6.65	6.65	63%	31.8
3	11	6	3	4	No	Full	90-120	20-60	NM	NM	4.56	4.56	50%	68.2
4	13	1	2	12	No	Full	0-90	Full	9	9	4.56	6.65	28%	18
5	1	20	5	6	No	Full	0-90	Full	3	3	2.8	2.8	50%	22
6	18	2	3	30	No	Full	Full	Full	14	14	6.65	6.65	0%	40
7	15	0.5	3	12	No	Full	Full	Full	7	7	4.31	4.31	50%	20.5
8	18	2	1	2	Yes	Full	Full	Full	5	5	4.3	4.3	38%	6.8
Average	12.75	5.9375	2.5	11.275	1/8								35%	26.225

MCP: metacarpophalangeal joint; PIP: proximal interphalangeal joint; DIP: distal interphalangeal joint; 2PD: two-point discrimination; RDN: radial digital nerve; UDN: ulnar digital nerve; MF: monofilament (Semmes Weinstein); QuickDASH: the Disabilities of the Arm, Shoulder and Hand Score; NA: not measurable; TAM: total active motion.
^a Reduction relative to the unaffected hand.

Table 3
Patient data.

Patient	Age at injury	Dominant hand	Injured finger	Injected product	Occupation
1	47	Right	2nd Right	WBP	Painter
2	27	Right	3rd Left	OBP	Welder
3	52	Right	2nd Right	Grease	Policeman
4	36	Right	2nd Right	Grease	Driver
5	37	Right	2nd Left	OBP	Painter
6	31	Right	3rd Right	Grease	Machine operator
7	36	Right	2nd Left	Grease	Mechanic
8	33	Right	2nd Left	WBP	Construction worker

WBP: water-based paint; OBP: oil-based paint.

and ADL. Both patients also had the fastest return to work, one at 1 week and the other at 2 months.

None of our patients required amputation of the involved finger, in contrast to Mirzayan et al. [4] who reported up to a 50% amputation rate and Wieder et al. [5] who reported a 22% rate. This is most likely due to the quick initial debridement, as a correlation between late debridement and an increased amputation rate has been reported. Hogan et al. [25] reported a 40% risk of amputation if debridement is performed within 6 hours of the injury and 57% when performed later than 6 hours. Wieder et al. reported an average time from injury to surgery of 6.5 hours (maximum of 48 hours) compared to 5.9 hours in our study (maximum of 20 hours). Six out of our 8 patients had a surgery within 6 hours of the injury. Still, due to the small number of participants in this study, this finding is not statistically significant [5].

In our study, 50% of patients healed without any loss of ROM. In those who had a permanent flexion contraction, the PIP and DIP

joints were most affected and the MCP joint was the least affected. This is similar to other studies [3,5]. Pinto et al. found that 64% of patients had normal hand function at the final follow-up 1 year later, although his article is difficult to compare to ours due to lack of a thorough examination at the final visit. Like in our study, Pinto et al. reported that 92% of patients returned to their previous jobs, which is comparable with our results in which 7 out of 8 patients returned to their pre-injury occupation.

The most disabling aspect of this injury seems to be the chronic neuropathic pain and cold intolerance, which was noted in all our patients to varying degrees. This has been reported in several articles that examined the sequela of this injury type [1–3,5]. No study, to our knowledge, has evaluated if this is the result of the original insult or from an iatrogenic injury induced by extensive soft tissue debridement. These studies would be very hard to conduct ethically because they require a group that receives minimal treatment thus increasing the risk of digit amputation.

Considering the above, surgical debridement is easily favorable compared to the danger of gangrene developing in the untreated finger and subsequent amputation.

In terms of ADL, all but one patient in our study had a slight increase in QuickDASH score and all were able to return to work. This adds further evidence that extensive surgical debridement is most likely the right treatment for high-pressure injury to the fingers.

A high-pressure injury to the fingers will have considerable sequelae in most individuals, such as an extended period of unemployment and some level of permanent disability, such as neuropathic pain, reduction in ROM, reduction in grip strength, and lack of sensation. Injuries involving oil-based paints and grease have worse outcomes than water-based paints. In this study, we found favorable outcomes after extensive debridement of high-pressure injection injuries and we present these cases in support of this treatment option.

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Disclosure of interest

The authors declare that they have no competing interest.

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