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Latex Paint-gun Injuries of the Hand: Are the Outcomes Better?

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Abstract This study aims to present the functional outcome in patients who sustained paint-gun injuries to the hand with latex paint and review the current trends, recommendations, and pitfalls of surgical treatment in contemporary literature. Five male patients with an average age of 35 years were treated between 2000 and 2003 after sustaining a paint-gun injury with latex paint. All wounds were located volarly on the digits of the nondominant hand. Preoperative radiographs were obtained in every patient. All patients underwent debridement of the affected digit. Despite delayed presentation, more than 24 h post injury, our patients recovered substantial function at an average follow-up of 12 months. Every patient returned to his previous occupation and there were no amputations. Paint-gun injuries with latex paint appear to be associated with an outcome that is superior to the poor outcome traditionally associated with oil-based paints.

Keywords Paint-gun · Latex · Paint · Injection · Injuries · Hand

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Introduction

Paint-gun injuries are part of a spectrum of conditions known as high-pressure injection lesions that typically occur in the hand [17, 25, 30]. Paint is the second most frequently injected agent after grease [7, 10, 12, 13, 16]. Epidemiologically, paint-gun injuries occur most often in young males.

The prevalence of these injuries is difficult to assess. More than 100 case reports of high-pressure injection injuries have been published, yet most are focused on high-pressure injuries overall without special reference to the injected material [9]. Schoo et al. deduced the incidence of high-pressure injuries to be 1 in 600 hand injuries seen in the emergency department of their institution [25]. However, exact data from prospective or population studies determining the incidence or prevalence of paint-gun injuries is not available [9].

Factors attributed to causation of this injury include careless cleaning of the tip of the gun injector because of inexperience or excessive confidence [1, 2, 18, 19, 20, 25, 34]. Typically, the involved hand is the nondominant [8, 25], and the injury may be palmar or digital, almost always on the volar aspect [7, 5, 9, 16, 22, 31]. The initial presentation of these injuries is innocuous; this often delays medical evaluation and may promote inadequate treatment from inexperienced primary care providers, ultimately affecting the proper timing of the required aggressive surgical treatment for these limb-threatening injuries [3, 17, 18, 23, 30, 31, 34].

We report our experience with five patients who sustained latex paint-gun injuries of the hand. Despite a delay in presentation and treatment, and contrary to other reports, outcomes were promising in these injuries with latex-based paint.

Materials and Methods

Demographics

Five male patients with a mean age of 35 years (range 27 to 44 years) were treated by two surgeons (CM, 4 and DR, 1) after they sustained an accidental paint-gun injury with latex paint. All of them injured their nondominant hand. All entry wounds were volar and digital in regards to location. Two patients injured the index finger, two the middle finger, and one the ring finger. None of the patients was able to provide any details about the pressure setting on the paint-gun or the volume of the injected material. The four patients who injured the index finger and middle finger did so while testing the paint-gun on the affected digit to confirm that the nozzle was cleaned after cleaning its tip. The only other injury was accidental. No patient presented to the emergency room promptly after injury. Four patients were seen at least 24 h after the injury and one was seen after 72 h. All five patients presented with severe local pain, swelling of the involved digit with a mottled appearance, and painful limitation of range of motion. Despite the delayed presentation, none of the patients demonstrated clinical signs of local infection or systemic sepsis. Four of the injuries occurred distal to the distal interphalangeal (DIP) joint and one just proximal to the DIP flexion crease. All patients presented with an innocuous wound less than 3 mm in size; there was no exit wound (Fig. 1).

Management and Treatment

Preoperatively, all patients had radiographs (Fig. 2a and b). Paint was visualized in the radiographic studies of every patient, and the anatomic extent of visualization on the radiographs was variable. After the initial assessment, all patients underwent prompt surgical treatment. This consisted of open debridement through a Bruner approach in four patients and midlateral approach in one. Paint was found to extend from the pulp to the third annular pulley (A3) in four patients and to the second annular pulley (A2) in one (Fig. 3). Paint was located mainly along the neurovascular bundle. Despite its proximity to the pulley system, paint was not observed within it.

Furthermore, intraoperatively, it was noted that the extent of clinical spread of the paint was proximal to that noted on radiographs in every patient (Fig. 3). Careful debridement of paint was done preserving the skin flaps and the affected neurovascular bundle. In areas where the paint was densely adhered to the soft tissues, it was partially excised.

No attempt was made to remove it in its entirety for fear of further devascularizing the traumatized soft tissues and skin (Fig. 4). After substantial irrigation, four of the five surgical wounds were partially closed. One patient required a second irrigation and debridement procedure; final closure was achieved after this second procedure.

Postoperatively, four patients underwent sterile whirlpool treatments to the partially open wound. Intravenous antibiotics for 48 h, strict edema control measures, and early active and active assisted range of motion were also incorporated into the postoperative regimen. None of our patients received systemic steroids, and sutures were removed 10 days after surgery.

Patients were assessed periodically for a mean of 12 months (range 8–18 months) for range of motion, function, and sensation recovery.

Results

All patients recovered functional motion in the affected digit (Fig. 5a, b, and c). Every patient returned to his previous occupation after treatment. None of our patients required subsequent amputation of the digit. Four patients developed pulp atrophy and had mild hypoesthesia of the pulp (Fig. 6). One patient had anesthesia affecting half the digit, but had no functional complaints from the same.

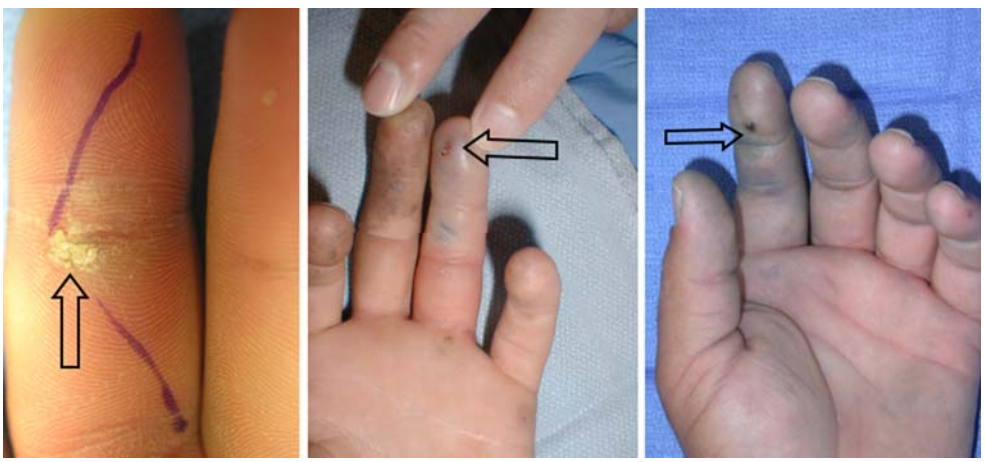

Figure 1 Examples of entry wounds seen in patients with paint-gun injuries, which highlight the benign characteristics of the entry wound.

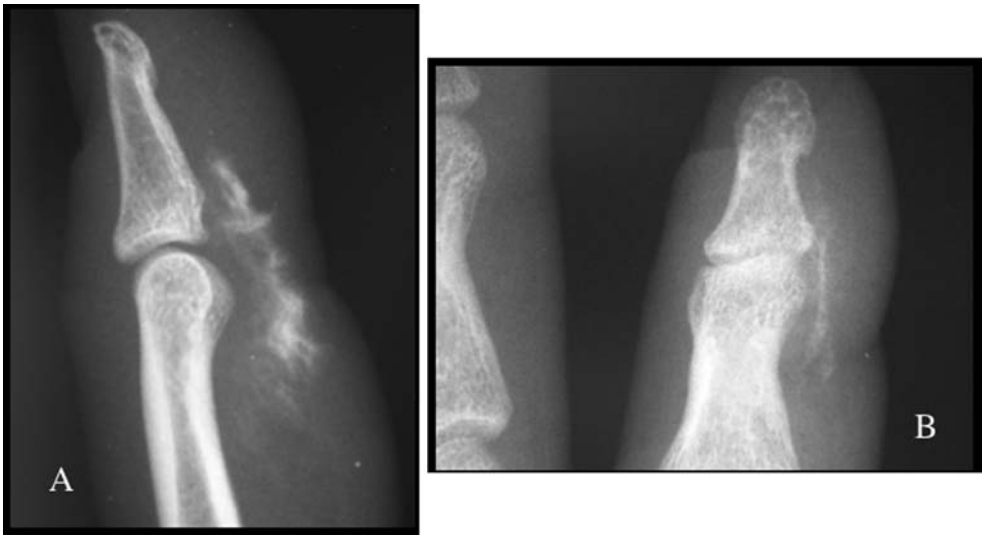

Figure 2 **a** and **b** Radiographs demonstrating the radio-opaque paint in a patient who sustained a paint-gun injury with latex paint. Although it appears that there is no obvious paint extension proximal to the middle phalanx, intraoperatively, paint was observed at the level of the distal portion of the A2 pulley.

Discussion

The first cases of paint-gun injury were described by Gruner after the commercial introduction of spray guns [6]. Subsequently, paint-gun injury has been reported as case reports or as a part of series or reviews of high-pressure injuries in general [9]. In an overview of injection injuries, Hogan and Ruland noted that there were 345 published cases of high-pressure injection injuries in the upper extremity [9]. Of these, 169 were caused by a paint-gun; paint was the injected material in 140 cases and paint thinner was injected in the remaining 29 [4, 7, 14, 15, 20, 24, 28, 29, 30, 31, 32]. Although paint-gun injuries have been reported, they are infrequent. The largest series of paint-gun injuries reported on 35 cases, but failed to elaborate on the nature or composition of the injected substance—thinner vs. paint and oil-based vs. water- or latex-based paint [17]. The lack of data and adequate studies appears to be the product of the low incidence and prevalence of paint-gun injuries.

Time to debridement is crucial in determining outcome and amputation rate [3, 9, 17, 25, 28]. Analysis of current data makes it difficult to estimate a benchmark as most reports consist of few cases and use terms such as "emergent," "prompt," or "immediate treatment" instead of measurable time parameters [9]. However, from a review of available data and our results, it appears that a time frame of 6 h is critical. When treatment is performed within 6 h, amputation rate has been estimated to be about 40% [9, 17, 25, 28]. If treatment is delayed more than 6 h, rates increase to approximately 57%. Finally, with 1-week delay or essentially, without treatment, the amputation risk can be as high as 88%.

Figure 3 Intraoperative photograph demonstrating the extension of the paint to the A2 pulley (*arrow*) in the patient whose radiographs are seen in Fig. 2. This emphasizes the role of plain radiographs to aid in the assessment of the extent of spread, but also illustrates their limitation in being able to delineate extent of spread [27].

Figure 4 Intraoperative appearance of the digit seen in Figs. 2 and 3 after debridement of paint. Visible residual paint was firmly adherent to the soft tissues and was left in situ.

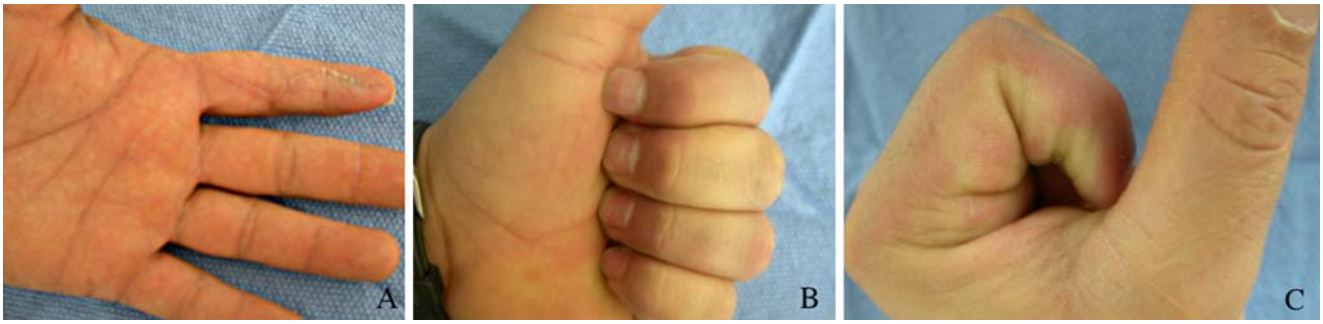

Figure 5 **a**, **b**, and **c** Clinical outcome of the same patient at 4 months. The patient recovered excellent motion with almost full flexion–extension.

Skin contact with the paint-gun does not appear to be essential and skin penetration can occur with pressures as low as 100 pounds per square inch (psi) [26]. The average nozzle injection pressure varies from 600 to 7,000 psi; however, when the nozzle gets blocked, pressure can increase up to 12,000 psi. Translated into velocity, a water pressure of 10,000 psi can inject water at a speed of 1,360 ft/s or 928 mph [11]. At this high pressure, the injected material tends to spread through soft tissues.

Patterns of injection vary based on direction and wound location. Most often, paint is injected perpendicularly to the skin and pulley system. Kaufman [11, 12] suggested, based on cadaveric experiments with wax injections, that entry wounds over the pulley system cause variable material spreading. He theorized that entry wounds over the weaker cruciate pulleys might be associated with spreading within the pulley system. Conversely, entry wounds located over the annular pulleys might spread outside the pulley system in a lateral direction along the neurovascular bundles. He also suggested that digital injections are likely to cause greater damage because of reduced space than injections to the palm where the space is greater. In our series, we did not observe any paint within the pulley system. That was in keeping with the location of entry wounds over the annular pulleys. We also did not see any spread into the palm or further proximally.

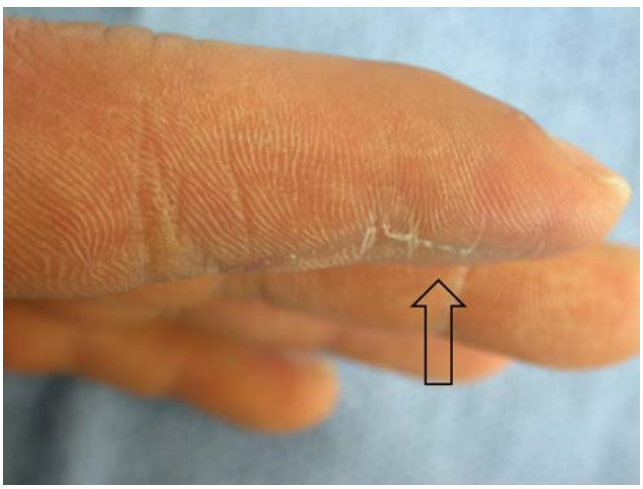

Figure 6 Pulp digital atrophy was seen as complication in most patients.

Treatment is best performed in the operating room. Although wounds may seem innocuous and radiographs may suggest limited spread, both of these underestimate the injury and may confound the unsuspecting or inexperienced surgeon. Attempts at local debridement in the emergency room under local anesthesia are to be avoided. Not only is the procedure likely to be inadequate, but the injection of local anesthetic into an already swollen and edematous field is likely to increase local volume and compromise vascularity, thereby exacerbating tissue ischemia [20].

With regards to other therapeutic measures, we utilized parenteral antibiotics for 48 h. We did not document any infection, but our small sample size does not allow us to speculate about the efficacy of antibiotics in this clinical setting. Some advocate their use as there is a significant formation of necrotic tissue that may easily promote contamination and subsequent infection [2, 11, 13, 23, 31, 33]. Others have suggested that the strong alkaline nature of many of the accidentally injected substances may create a bactericidal environment that decreases the risk of infection [5]. According to the most recent reviews of available literature, there is no correlation between the rates of infection or positive intraoperative cultures and the rate of amputation [9, 17]. In fact, some investigators have noted that the rates of amputation in patients with digital infections are the same as those with injection injuries in general [9]. However, it must be recognized that this data consists mainly of case series and case reports and, therefore, it does not provide the most adequate level of evidence from which to draw conclusions.

The role of steroids is also unclear. Their use is based on plausible theories that apply to other clinical scenarios but which have not been proven in the case of paint-gun injuries [21]. Reports that suggest the use of steroids vary substantially in terms of dose, protocol, time frame of use, injected substance, and duration of treatment. These confounding variables in addition to the low level of published evidence make it difficult to identify the potential

role of steroids in paint-gun injuries [2, 5, 9]. We have not utilized steroids in the management of our patients and are unable to find sufficient evidence to support or propose their use in this injury.

Based on our experience with five latex paint-gun-injured patients and after evaluating the available literature, we have observed an evolving trend in terms of prognosis after paint-gun injuries. This improvement and particularly the reduction in amputation rates appears to depend mainly on the nature of the injected material [3, 7, 9, 17, 25]. Paint has been traditionally recognized as one of the most toxic substances along with other organic solvents such as paint thinner, diesel fuel, gasoline, and jet fuel [24]. The intense inflammatory response, vasospasm, and production of necrotic tissue have prompted some authors in the past to recommend early amputations because of severe initial ischemia despite early surgical intervention [4]. Paint is described in different investigations as a substance that contains approximately 40 raw materials, which are commonly classified as solvent, pigment, and transport vehicle [2, 3, 5]. Several years ago, paints were mainly oil-based, which differ from latex paint in regards to transport vehicle and solvent, widely recognized as the most toxic components of paint. Furthermore, oil-based paint components such as soy alkyd, mineral spirits, resins, and hydrocarbon solvents are also toxic to tissue [2, 5, 18]. Compared to other series in which the paint was oil-based and the amputation rate was high [4], in our series with latex paint-gun injuries, there were no amputations. Our results are comparable to published series that, on average, report a 5% amputation risk with latex paints vs. 60% with oil-based paints [9]. Although we have presented only five patients, it appears that outcomes after latex paint injection are better and the morbidity far less than injection of oil-based paints.

Paint-gun injuries are a rare but limb-threatening condition, the gravity of which needs to be recognized early by the patient and especially by the primary care providers in clinics and emergency departments to offer prompt adequate treatment. We firmly believe that occupational injury prevention campaigns to make the community at risk aware of the serious consequences of these injuries are required. Workers should be adequately trained in the use and cleaning of paint-guns. Emphasis should be placed on alerting workers to switch off the machine compressors during the cleaning process. Furthermore, workers should also be alerted to the considerable danger of testing paint-guns on their fingers.

The more common contemporary use of latex-based paints compared to oil-based paints may play a large role in the improvement of prognosis in patients who have sustained this injury; this prognostic improvement may be attributable to the different chemical composition of latex paints, which appear to be less toxic to human tissue than oil-based paints. Recommendations in terms of the efficacy and utility of antibiotic prophylaxis and intravenous steroids remain speculative because of the inconclusive results at very low levels of evidence. However, because of the low risk that these therapies pose to patients, the individual surgeon may consider their use whereas keeping a rational restriction in terms of costs until more evidence is available. The only factors that have consistently been demonstrated to affect prognosis in the literature are the chemical nature of the injectate and time to surgical treatment [2, 5, 9, 17, 25, 28]. Final outcomes correlate directly to prompt and aggressive treatment after early recognition and diagnosis. Latex paint-gun injuries appear to have a lower morbidity and better outcomes than the traditionally poor outcomes associated with oil-based paints.

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