THE TEN-YEAR EXPERIENCE OF FIREWORK INJURIES TREATED AT A UK REGIONAL BURNS & PLASTIC SURGERY UNIT

ÉTUDE SUR 10 ANS DES BRÛLURES PAR FEU D'ARTIFICE TRAITÉES DANS UN SERVICE DE BRÛLÉS DU ROYAUME UNI

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SUMMARY. Fireworks are used worldwide to celebrate national, religious, cultural festivals and holidays. However the use of fireworks is associated with preventable injuries. We aim to review cases of burns and trauma caused by fireworks presenting to a regional burns and plastic surgery unit in the United Kingdom. We hope our findings will help to guide future firework-related safety practices in the UK. A retrospective review was performed of all patients presenting to our tertiary burns and plastic surgery unit with burns and/or trauma sustained from fireworks over a ten-year period from October 2004 to October 2014. A total of 93 patients were identified. Medical case notes were reviewed, patient demographics, aetiology of injury, management and patient outcomes were recorded. A cohort of 93 patients with burn injuries caused by fireworks were identified from our database. A total of 74% injuries occurred in October and November. Mechanism of injury included contact, flash, flame burns and injury secondary to blast force. Most injuries sustained were to the hands, followed by head and neck, torso, limbs and perineum in descending order of frequency. A total of 38.7% of patients required surgery for their wounds. Fireworks not only result in significant burn injuries, but also eye injuries, soft tissue defects and fractures requiring a spectrum of plastic surgical interventions. The number and severity of accidents can be minimised by raising awareness regarding safety precautions.

Keywords: fireworks, burns, trauma, plastic surgery

RÉSUMÉ. *Les feux d'artifices (FA) sont utilisés mondialement, dans des contextes festifs variés (religieux, nationaux, culturels, locaux). Les accidents qui y sont liés sont évitables. Nous avons étudié les brûlures et les traumatismes liés aux FA se présentant dans notre CTB, espérant que ceci permettra la mise en place de mesures de prévention dans l'ensemble du Royaume Uni. Nous avons revu rétrospectivement les dossiers des 93 patients pris en charge dans notre CTB entre octobre 2004 et octobre 2014 après un accident de FA. Les données démographiques, étiologiques, de prise en charge et évolutives ont été colligées. Les ¾ des accidents étaient survenus en octobre et novembre. Les mécanismes vulnérants étaient le contact, le flash, la flamme et le blast. Les mains étaient la région la plus fréquemment touchée, suivies par ordre décroissant par la région cervico-céphalique, le torse, les membres et le périnée. Trente huit virgule sept pour cent des patients pont du être opérés. Les accidents de FA entraînent non seulement des brûlures mais aussi des atteintes oculaires, des pertes de substance cutanées et des fractures pouvant nécessiter des interventions dans un large spectre de la chirurgie reconstructrice. Le nombre et la gravité de ces accidents peut être diminués par une application accrue des mesures de précaution.*

Mots-clés : *feux d'artifice, brûlure, traumatisme, chirurgie plastique*

Introduction

The earliest documentation of fireworks can be traced back to their invention in 7th century China during the rule of the Tang dynasty.[1] Fireworks began to gain popularity around the 17th century in the western hemisphere.[2] In the modern era people use fireworks worldwide to celebrate national, religious, cultural festivals and holidays.[3] These include the fourth of July in the United States,[4] Diwali the festival of light in India,[5,6] Hari Raya festival in Malaysia,[7] Greek Orthodox Easter in Greece[8] and New Year's Day in many countries around the globe.[4,9-11]

However the use of fireworks is associated with preventable injuries. Many studies from around the world have recognized the importance of this global problem.[12-18] In the United Kingdom (UK) fireworks are mainly used to remember the failed conspiracy to blow up Britain's Houses of Parliament annually on the 5th of November.[19] Unfortunately these festivities often result in many associated preventable injuries.[20,21] We aim to review cases of burns and trauma caused by fireworks presenting to a regional burns and plastic surgery unit in the UK, in order to ascertain at risk individuals, patterns of injury and treatment outcomes in this specific population. We hope our findings will help to guide future firework-related safety practices in the UK with a focus on education and prevention.

Methods

A retrospective review was performed of all patients pre-

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senting to our tertiary burns and plastic surgery unit with burns and/or trauma sustained from fireworks over a ten-year period from October 2004 to October 2014. The search term 'Firework' was used to conduct a search within the International Burns Injury Database (IBID) entries from our regional burns unit as well as all clinical cases coded as 'firework' related injury that presented to the plastic surgery department. A total of 93 patients were identified. Medical case notes were reviewed, patient demographics, aetiology of injury, management and patient outcomes were recorded.

Results

A cohort of 93 patients with burn injuries caused by fireworks were identified from our database. *Table I* provides the demographic information for this cohort. The mean age was 21 (range 6 months to 57 years). A total of 48.4% of the cases were adults (age ≥ 18) and 51.6% were children. The identified cases included 82 males (88.2%) and 11 females (11.8%).

Sixty-nine (74.19%) injuries occurred in October and November, with half (50.54%) occurring in November alone. The remaining 24 (25.81%) injuries occurred in the other months of the year. This period (October & November) corresponds with a period of high use and availability of fireworks in the run up to bonfire night in the UK. *Fig. 1* demonstrates the frequency of firework injuries per each month of the year over the study period. It is clear there is a large rise in injury during this specific holiday period.

Mechanism of injury included contact, flash, flame burns and injury secondary to the blast force. The overall proportion of injury by mechanism is provided in *Fig. 2*. Flash burns contributed the highest proportion of injuries in the cohort, followed by flame burns, then contact burns. Furthermore, less than 10 patients suffered fractures or burst lacerations secondary to the explosion caused by the firework.

Of the 83 patients with burn injuries alone, 48 sustained superficial partial thickness burns, 17 were deep dermal and 19 were full thickness burns. With regard to depth of injury, our study demonstrated that 51.6% of the patients sustained partial thickness injuries, 18.3% suffered deep dermal burns and the remaining 20.4% suffered full thickness burns. The median percentage total body surface area (%TSBA) was higher for flame burns at 2.1% compared to a median %TSBA of 1% from flash burns and <1% from contact burns. Superficial partial thickness burns had blisters debrided on admission and were managed conservatively with dressings. Deep dermal or full thickness injuries were managed by tangential excision and split thickness skin grafting.

Most injuries sustained were to the hands, followed by head and neck, torso, limbs and perineum in descending order of frequency. The percentage involvement of anatomical areas is demonstrated on the body map in *Fig. 3*.

In this study, 38.71% of patients required surgical intervention (*Table II*), with 11.8% requiring wound debridement and skin graft reconstruction for their injuries. A total of 16.13% of patients required debridement and closure of wounds. One patient required a partial repair of the abductor pollicis muscle. A single terminalisation of a digit was performed. Two other patients underwent soft tissue reconstruction of finger injuries with a homodigital flap and pedicled groin flap that was divided 3 weeks later. Five patients sustained hand fractures: all underwent manipulation under anaesthetic and Kirschner wire fixation. Fracture patients received 6 weeks of splinting, followed by hand therapy to improve mobilization. Hand physiotherapy follow up was on average 6.5 months (range 2 – 10 months). Apart from the patient with fingertip terminalisation, no other functional or range of motion deficits were recorded in our series following hand therapy.

Table I - Patient demographics

Variable	Number / mean	Range / %
Age (years)	Mean 21	0.5-57
Age > 18	45	18-57
Age < 18	48	0.5-17
Male	82	88.17
Female	11	11.83
First aid	66	70.97
Admitted	27	29.03
Length of stay (days)	Mean 2.23	1-9
Eye injury	3	4.1%
Hand fracture	6	6.45%
%TBSA	Mean 1.28	1-6
Time to heal (days)	Mean 18.58	7-58

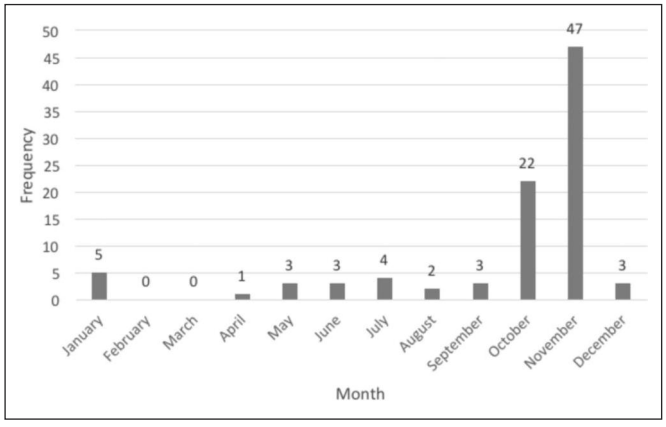

Fig. 1 - Number of referrals for firework-related burns by month of the year.

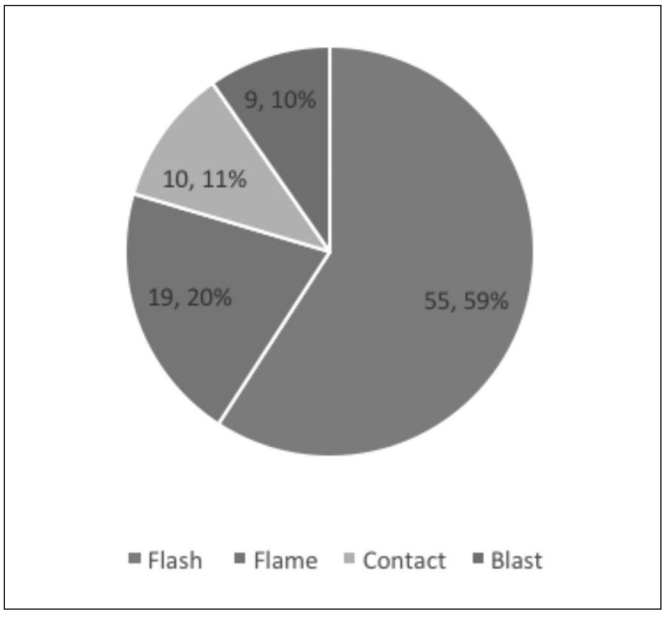

Fig. 2 - Mechanism of injury.

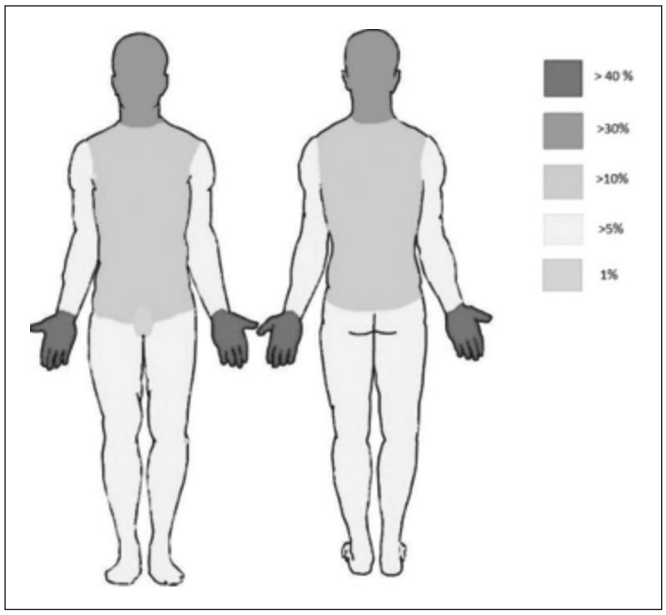

Fig. 3 - Body map showing percentage involvement of anatomical region.

Table II - Treatment

Treatment	Number	%
Conservative	57	61.29
Surgical intervention	36	38.71
Wound debridement +/- closure	15	16.13
Digit terminalisation	1	1.08
STSG/FTSG reconstruction	11	11.83
Homodigital finger flap	1	1.08
Pedicled groin flap to hand reconstruction	1	1.08
Abductor Pollicis Longus muscle repair	1	1.4
Hand fracture K-wire fixation	5	5.38

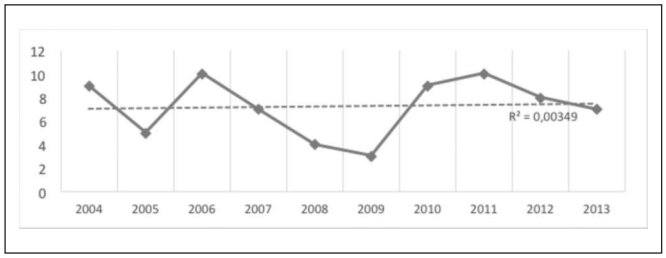

Fig. 4 - Frequency of admissions annually.

Three patients suffered eye injuries that were limited to corneal abrasions. All three were seen once in an ophthalmology follow up clinic and then subsequently discharged with no permanent visual loss.

Fig. 4 shows the frequency of admissions for firework-related injuries annually over the 10-year period. This graph demonstrates that despite fluctuations in the number of patients admitted on a yearly basis, the overall trend-line shows there has not been a significant reduction in cases over the decade ($R^2 = 0.0035$).

Discussion

In this study, 88.2% of the admissions were males. This is comparable to the sample group reported in China[22] and Iran,[23] consisting of 88% and 79% males respectively. This male preponderance in frequency and severity of injury may be attributed to increased risk-taking behaviour amongst males. This highlights a need for awareness and prevention programmes to target young males who appear to be at greater risk.

Our age distribution demonstrates children as the most vulnerable population with 51.6% of our admissions being under the age of eighteen. This is unsurprising due to children being less experienced with the handling of fireworks, more adventurous and less able to respond to dangerous hazards. This trend is supported by data from other cultures such as India and USA where children under fourteen formed 40 to 50% of the cases.[21,24] Perhaps this is an indicator that more needs to be done to educate children about the dangers that fireworks pose, and this can be implemented at an earlier school age.

Our results suggest the most commonly affected body parts are the hands (47.8%) followed by head and neck (31.9%). Other studies have shown hands to be affected in up to 80% of the patients.[21] Other studies from countries such as Iran, Australia and Saudi Arabia have also demonstrated the hands to be the most common site of injury.[23,25,26] The hands are in the most vulnerable position, particularly when igniting the firework. They are also the only area frequently left exposed along with the head and neck. Protective measures should be employed when using fireworks to minimise the risk of injuries to these exposed areas. Gloves or distance ignition techniques should be encouraged. In this study the mechanism of burn also appears to impact the anatomical site of injury, with flame burns leading to burns across several regions involving 26% of injuries across the trunk and 11% of those to the arms. This may be due to clothing catching fire and leading to burns over a greater surface area as the flames spread. This highlights the potential serious risk of flame burn injury that fireworks pose, leading to more serious injuries.

The results have demonstrated a seasonal trend of firework burn referrals in particularly high numbers in October and November, with 74% of the annual cases presenting in these two months. This strongly correlates with Halloween and Guy Fawkes Night, held in October and November respectively. This highlights the trend seen in several countries where fireworks are used to celebrate national, cultural and religious holidays.[4,21,22] This seasonal trend results in a large increase in casualties over a short time span, and this may overwhelm emergency responders or local units who do not have specialist experience to treat these injuries. In this eventuality workforce planning must take this into consideration as often these injuries are treated at specialist tertiary plastic surgery units. Studies have demonstrated that fireworks can result in permanent functional or visual disabilities.[26-28] Therefore early ophthalmic referral and examination is important to initiate treatment as required. On admission we examine all patients with fluorescein dye to examine for corneal abrasions. In the event of chemical or burn related ocular injury prompt irrigation is required with water, saline or amphoteric solution if available.[29] Fireworks result in a spectrum of injuries and in our unit we feel a multidisciplinary approach is beneficial. Plastic surgeons, specialist burn wound nurses, physiotherapists and occupational therapists are needed to rehabilitate these patients and ensure they achieve a satisfactory outcome, particularly after hand injuries to avoid stiffness. We feel prevention is the key to aiming to reduce the incidence of these

preventable injuries. Increased public awareness through aggressive campaigning has been shown to reduce the incidence of burns from fireworks around Diwali time in India.[21] Aggressive awareness campaigns performed by government and non-government organisations were identified as the cause. There was no obvious reduction in incidence of referrals over the ten years of our study. This is particularly concerning as it demonstrates that current initiatives are not reducing the incidence of these preventable injuries. It would be in the public's interest to increase education and awareness of the safe handling of fireworks, their risks, and first aid measures in the event of injury. Particular attention should be targeted towards the most at risk group of young males and parents.

Conclusion

Our series has demonstrated that fireworks not only result in significant burn injuries, but also eye injuries, soft tissue defects and fractures requiring a spectrum of plastic surgical interventions including skin grafts, local and pedicled tissue transfer and fracture fixation. A multidisciplinary approach is often needed, including allied health professionals, particularly hand therapists / physiotherapists to achieve a satisfactory outcome. Prevention is the key to aiming to reduce the incidence of these preventable injuries. Increasing public awareness by aggressive campaigning has been shown to reduce the incidence of burns from fireworks in other countries. We call for campaigns in the UK to target the young to reduce the incidence of these largely preventable injuries. The number and severity of accidents can be minimised by raising awareness regarding safety precautions, motivating manufacturers to adhere to strict quality control, and encouraging the use of fireworks as part of professionally organised displays. Also importantly, workforce planning must be prepared for the annual upsurge of complex cases following firework injuries, and adequate preparations made to perform first aid and triage, and refer these patients appropriately.

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Conflict of interest. All of the authors declare that they have no conflict of interest.

Ethical Standards. The manuscript does not contain clinical studies or patient data. No clinical photographs have been included.