

AN EPIDEMIOLOGICAL STUDY ON CRACKER BLAST HAND INJURIES IN OUR INSTITUTION AND ADDRESSING THE ROOT CAUSE – A SCIENTIFIC EXPEDITION

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ABSTRACT

Background: Firecracker-related hand injuries are a significant public health concern in India, particularly during festivals. The rise in unregulated, country-made crackers has heightened the risk of severe, preventable injuries. This study aimed to assess the demographic and clinical profiles of affected patients and identify the key contributing factors. **Materials and Methods:** This prospective observational study included 93 patients with firecracker-related hand injuries admitted between September 2023 and August 2025. Demographic and clinical data were also recorded. A blast simulation using dummy hand models was conducted to compare the damage caused by factory-made and country-made crackers. **Result:** All 93 patients were male, with the most affected age group being 21–30 years [41(44%)], followed by 11–20 years [19(20%)] and 31–40 years [20(22%)]. Country-made crackers caused 48(52%) injuries; factory-made, 45(48%). Vadakkampatti [47(51%)] and Sivakasi [40(43%)] were the main purchase points. Injuries occurred during Diwali [38(41%)], funerals [35(38%)], and local festivals [18(19%)]. The right hand was involved in 80(86%) cases, and multiple fingers were involved in 65(70%) cases. Grade 3 and 4 injuries were higher with country-made crackers [49(53%) and 29(31%)] than with factory-made crackers [14(15%) and 4(4%)]. Alcohol use was noted in 53(57%) patients. Treatments included debridement and suturing [30(32%)], amputations [26(28%)], K-wire fixation [17(18%)], and flap cover [5(5%)]. Return to original work was full in 35(38%), limited in 35(38%), and not possible in 23(25%) patients. **Conclusion:** Cracker-blast hand injuries from unregulated fireworks can cause severe harm. Stricter safety laws, public awareness, and the use of protective gear, such as Kevlar gloves, can help prevent these injuries.

INTRODUCTION

Hand injuries caused by firecrackers are a significant public health concern in South Asia, particularly in India, where the use of pyrotechnics is deeply ingrained in cultural and religious celebrations. These injuries range from minor burns to devastating mutilations, often resulting in permanent disability, particularly when the hands, which are critical for daily functioning, are involved. Most victims are young males exposed during festival seasons, such as Diwali, when the sale and usage of fireworks spike dramatically.^[1,2]

India presents a unique context in which both factory-manufactured and illegally assembled country-made crackers are widely available. Although factory-made crackers typically adhere to regulatory

standards, country-made variants are often prepared in unregulated settings with improper handling of explosive materials, leading to unpredictable and higher injury potential.^[3,4] Tamil Nadu, home to one of Asia's largest fireworks industries, also sees the proliferation of unauthorised cracker production and sales, especially in peri-urban and rural areas.^[5]

The anatomy of these injuries is often complex, involving multiple tissue planes, bones, tendons, nerves, and vessels, necessitating multidisciplinary surgical management. Depending on the type and intensity of the explosion, victims may suffer partial or total hand amputations, necessitating reconstructive surgery and long-term rehabilitation.^[6] The psychological, functional, and socioeconomic consequences are profound, especially for labourers and students who rely heavily on hand dexterity.^[7]

Despite bans and public safety campaigns, underage handling, lack of awareness, easy accessibility, and inadequate law enforcement continue to drive these injuries. Moreover, the existing literature provides limited data on the injury patterns associated with different types of crackers, particularly between the regulated and unregulated products. Identifying these distinctions is critical for informed policymaking and developing preventive strategies.^[8,9]

This study aimed to analyse the demographic and clinical profiles of patients with cracker-blast hand injuries and identify key contributing factors, thereby providing evidence-based recommendations for prevention and management.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Plastic Surgery at a tertiary care centre in Tamil Nadu, India, over a period of two years, from September 2023 to August 2025. The study was approved by the Institutional Ethics Committee, and informed consent was obtained from all patients or their guardians, where applicable.

Study Population

A total of 93 patients with hand injuries caused by firecracker blasts were included in the study. Patients of all ages and genders with isolated hand injuries directly attributable to firecracker explosions were enrolled. Cases involving multi-organ trauma or injuries unrelated to firecrackers were excluded.

Method

Data were recorded using a structured proforma that included demographic variables (age, gender, and occupation), type and source of firecracker (factory-made vs. country-made), mechanism of injury, timing (festival or non-festival), and prior awareness of firecracker safety. Detailed clinical examination findings, injury grading, radiographic evaluation, and operative findings were recorded.

Hand injuries were classified as follows: the level of tissue damage was further categorised into soft tissue loss, bone involvement, tendon injury, nerve damage, and vascular compromise. Management strategies were individualised based on the injury type and included wound debridement, fracture fixation, tendon and nerve repair, flap coverage, or amputation when necessary.

To objectively compare the explosive potential and resultant damage of country-made and factory-made crackers, a blast simulation experiment was performed under controlled conditions. Identical dummy hand models were constructed using chicken flesh embedded with synthetic bones to mimic the resistance of human tissue. Equal-sized samples of country-made and factory-made crackers were detonated separately, and the resulting damage was assessed in terms of the surface blast radius, depth of penetration, bone fragmentation, and thermal effect. Video analysis and high-speed photography were used to document each detonation event. The visual and physical damage patterns were correlated with the clinical injury profiles observed in real patients.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using SPSS version 26.0. Categorical variables are presented as frequencies and percentages.

RESULTS

All patients included in the study were male (100%). The majority of patients were aged 21–30 years (44%), followed by 11–20 years (20%), 31–40 years (22%), 0–10 years (6%), 41–50 years (5%), and 51–60 years (2%). Regarding the type of crackers, 52% were country-made, and 48% were factory-made. Vadakkampatti and Sivakasi accounted for 51% and 43% of the cases, respectively, while the source was unknown in 6% of the cases. [Table 1]

Table 1: Demographic Profile and Firecracker Characteristics

Variable	Category	N (%)
Sex	Male	93 (100%)
Age Distribution	0 – 10	6 (6%)
	11 – 20	19 (20%)
	21 – 30	41 (44%)
	31 – 40	20 (22%)
	41 – 50	5 (5%)
	51 – 60	2 (2%)
Crackers Made	Country made	48 (52%)
	Factory made	45 (48%)
Place of Purchase	Vadakkampatti	47 (51%)
	Sivakasi	40 (43%)
	Unknown	6 (6%)

Injuries occurred during Diwali in 38 (41%), funerals in 35 (38%), local festivals in 18 (19%), and other occasions in 2 (2%) patients. The right hand was involved in 80 (86%) and the left hand in 13 (14%). Multiple fingers were affected in 65 (70%), followed by the thumb in 15 (16%), index finger in 6 (6%), middle finger in 3 (3%), ring finger in 2 (2%), and

little finger in 2 (2%). Grade 3 injuries were observed in 32 (34%), Grade 1 and Grade 2 in 22 (24%) each, and Grade 4 in 17 (18%). Skeletal injuries included the first CMC joint in 22 (24%), metacarpals in 22 (24%), phalanges in 15 (16%), and no bone injury in 34 (37%). [Table 2]

Table 2: Occasion, Hand Involvement, Finger Involvement, Injury Grade, and Skeletal Injury

Variable	Category	N (%)
Occasion of Injury	Funeral	35 (38%)
	Local Festival	18 (19%)
	Diwali	38 (41%)
	Others	2 (2%)
Affected Hand Side	Right	80 (86%)
	Left	13 (14%)
Affected Fingers	Thumb	15 (16%)
	Index	6 (6%)
	Middle	3 (3%)
	Ring	2 (2%)
	Little	2 (2%)
	Multiple	65 (70%)
Grade of Injury	Grade 1	22 (24%)
	Grade 2	22 (24%)
	Grade 3	32 (34%)
	Grade 4	17 (18%)
Skeletal Injury	First CMC JT	22 (24%)
	Metacarpal	22 (24%)
	Phalanges	15 (16%)
	No Bone Injury	34 (37%)

Among factory-made cracker injuries, Grade 1 was observed in 41 (44%), Grade 2 in 34 (37%), Grade 3 in 14 (15%), and Grade 4 in 4 (4%). Among country-

made cracker injuries, Grade 1 was noted in 3 (3%), Grade 2 in 12 (13%), Grade 3 in 49 (53%), and Grade 4 in 29 (31%).[Table 3]

Table 3: Injury Grading Based on Type of Crackers Used

Variable	Category	N (%)
Factory Made Crackers Grading	Grade 1	41 (44%)
	Grade 2	34 (37%)
	Grade 3	14 (15%)
	Grade 4	4 (4%)
Country Made Crackers Grading	Grade 1	3 (3%)
	Grade 2	12 (13%)
	Grade 3	49 (53%)
	Grade 4	29 (31%)

Alcohol consumption at the time of the accident was reported in 53 (57%) and absent in 40 (43%) patients. Treatments included debridement and skin suturing in 30 (32%), finger amputations in 26 (28%), CMC joint capsule repair in 15 (16%), K-wire fixation in

17 (18%), and flap cover in 5 (5%). Hospital stay was less than one week in 62 (67%) and more than one week in 31 (33%). Return to original work was complete in 35 (38%), with limitations in 35 (38%), and not possible in 23 (25%).[Table 4]

Table 4: Alcohol Use, Treatment Modalities, Hospital Stay, and Work Return Outcomes

Variable	Category	N (%)
Alcohol Consumption at Time of Accident	Yes	53 (57%)
	No	40 (43%)
Treatment Given	Debridement and Skin Suturing	30 (32%)
	Finger Amputations	26 (28%)
	CMC JT Capsule Repair	15 (16%)
	K Wire Fixation	17 (18%)
	Flap Cover	5 (5%)
Duration of Hospital Stay	< 1 Week	62 (67%)
	> 1 Week	31 (33%)
Return to Original Work	Yes	35 (38%)
	Yes, With Limitations	35 (38%)
	No	23 (25%)



Figure 1: Country made cracker

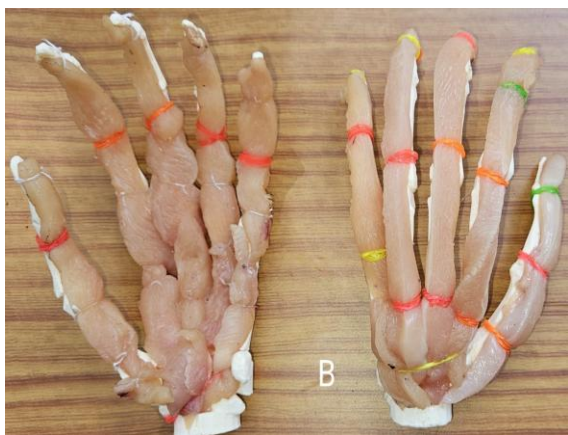


Figure 2: Hand replica



Figure 3: Post simulation blast comparison

DISCUSSION

Our study included 93 male patients, with the most affected age group being 21–30 years (44%), followed by 11–20 years (20%), and 31–40 years (22%). Country-made crackers accounted for 52% of the cases, whereas 48% were factory-made. The major sources of purchase were Vadakkampatti (51%) and Sivakasi (43%), with 6% from unknown sources. Joshi et al. studied 50 patients, predominantly male (80%), aged 6–65 years, with the 16–25 age group most affected (40%).¹⁰

Gopalakrishnan et al. reported 78% male patients aged 6–58 years, with a mean age of 26 years; injuries were mainly due to misuse (56%) and premature explosion while lighting (58.33%).^[11]

Das et al. reported 64 male and 6 female patients, aged 3–80 years, with a mean age of 23 years. Unlike our study, factory-made crackers were more common (67%) than country-made (33%).^[12] Pathan et al. studied 33 patients with hand injuries, of whom 94% were male (31) and 6% were female (2).^[13] Tandon et al. analysed 1373 patients over 9 years, showing 84.8% male predominance; the youngest was 14 months old, the oldest was 88 years old, and 73.02% were aged 5–30 years. Among 230 cases with detailed data, Anar and Bombs were the most common causes.^[14]

Adhikari et al. reported all 55 patients were male, aged 13–56 years, with a mean age of 27. Firecrackers, homemade bombs, and bottle bombs caused injuries, with firecrackers resulting in the most diverse injury patterns. Most patients were from economically disadvantaged backgrounds.^[15] Rajeswari et al. documented 213 firecracker injury cases over 3 years, with peaks during Diwali, Karthigai Deepam, and New Year. The most affected age group was 13–20 years, followed by children under 13, with a strong male predominance observed annually.^[16]

Most injuries in our study occurred during Diwali (41%) and funerals (38%), followed by local festivals (19%) and other occasions (2%). The right hand was predominantly affected (86%), with multiple fingers injured in 70% of cases; the thumb was the most frequently involved digit (16%). Injury grading showed that grade 3 was the most common (34%), followed by grades 1 and 2 (24% each) and grade 4 (18%). Skeletal injuries most often involved the first CMC joint (24%) and metacarpals (24%), whereas 37% had no bone involvement. Joshi et al. reported dominant hand involvement in 66%, with bilateral injuries in 8%; thumb (58%) and index finger (46%) were most frequently injured during firecracker throwing.¹⁰ Gopalakrishnan et al. found 65% dominant hand injuries (n=78), 33.3% bilateral injuries (n=40).^[11]

Das et al. identified Diwali (20 cases), funerals (17 cases), and temple festivals (23 cases) as major occasions. Right-hand involvement (66%) was lower than that in our study. The most injured fingers were the little finger (20), thumb (19), followed by the ring, middle, and index fingers.^[12] Khurshid et al. reported fractures in 73% and amputations in 27%, with 46% injuries classified as severe and 19% as major using the HISS scoring system; the amputation group had the highest mean HISS (~99.1).^[17] Pathan et al. observed right-hand involvement in 25 cases, left in 7, and bilateral in 1; the thumb (27), index (26), and middle (24) fingers were most frequently lacerated.^[13]

Injuries from country-made crackers were more severe, with Grade 3 and 4 injuries comprising 53% and 31%, respectively, while factory-made crackers

were linked to milder injuries (Grade 1 (44%); Grade 2 (37%). Das et al. reported 15 Grade 1, 23 Grade 2, 20 Grade 3, and 12 Grade 4 injuries, showing a more even distribution but with a notable 46% in higher grades (3 + 4).^[12] Sauhta et al. described severe trauma from a sutli bomb, including traumatic amputation, deep lacerations, devitalized tissue, and contracture requiring multiple surgeries (flap coverage, fixation, Z-plasty), reinforcing the severe impact of country-made crackers.^[18] Adhikari et al. found that only firecrackers caused the full spectrum of injuries, from mild to severe, with 90.91% of cases being moderate or severe. Firecrackers also caused more diverse injuries than other explosives. Severe injuries often lead to amputation, especially involving the radial side, and the need for terminalization surgeries.^[15]

Alcohol consumption at the time of injury was noted in 57% of the cases. Treatments included debridement and suturing (32%), finger amputation (28%), K-wire fixation (18%), CMC joint capsule repair (16%), and flap cover (5%). Most patients (67%) had hospital stays of less than one week. Regarding occupational impact, 38% returned to work without limitations, 38% with limitations, and 25% could not return. Joshi et al. reported that 40% (n=20) of patients underwent debridement with skin grafting, with some requiring up to four surgeries for fracture fixation, flap cover, or amputation. Hospital stays ranged from 5 to 21 days, with physiotherapy for long-term stiffness.^[10] Gopalakrishnan et al. found 15% (n=18) consumed alcohol; hospital stays exceeded two weeks in moderate to severe cases. Recovery varied mild cases regained near-normal function, while others had persistent stiffness.^[11]

Khurshid et al. assessed functional outcomes using the QuickDASH score (mean 37.2 ± 29.7); worse scores correlated with higher HISS grades, indicating prolonged or incomplete recovery despite return-to-work data not being specified.^[17] Adhikari et al. did not report alcohol use but described the phased management of complex hand injuries involving serial debridement, various flap techniques (groin, abdominal, chest, PIA), and extensive physiotherapy. Hospital stays often exceeded 2 weeks, with functional outcomes linked to injury severity and physiotherapy adherence.^[15]

Limitations: This study was conducted at a single tertiary centre with a relatively small sample size. Long-term functional and psychosocial outcomes were not evaluated.

CONCLUSION

Cracker blast hand injuries, mainly from unregulated local fireworks, often lead to serious damage and long-term disabilities. Enforcing stricter safety rules, raising public awareness, and educating the public about safe handling, especially during festivals, are key preventive steps. Encouraging the use of protective gear, such as Kevlar gloves, and involving

trained personnel in handling fireworks can further reduce the risk of injury.

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