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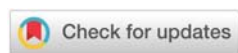
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**Research Article**

# The long term effects of firearm injuries on special senses

## Abstract

**Introduction:** Special senses are group of sensory organs that help us to connect with external environment by various modes of elements like sound, sight, touch and smell. Any damage to these organs though may not be physically handicapping but can affect the quality of life of any individual. Bullet injuries to the head and neck region are life-threatening and demand a detailed clinical examination and meticulous operative management due to the complexity of craniofacial anatomy. Head and neck region also house sense organs, but most of the time their functions are not properly assessed during the primary care provided in firearm injuries. The main aim of this study was –

To study the long term effects of firearm injuries on special senses.

To study the impact of these injuries on facial visage causing impairment on quality of life.

To set a standard protocol that can be applied in such injuries for a bedside evaluation of sense organs of victims.

**Materials and Methods:** The following study was conducted by the Department of Otorhinolaryngology & Head and Neck Surgery, Department of Forensic Medicine and Department of Community Medicine, at Grant Government Medical College and Sir JJ Group of Hospitals. A retrospective study of 532 patients who were victims of various firearm injuries in isolated civil incidents and terrorist attacks in Mumbai between January 1990 to July 2018. Institutional ethical clearance was obtained prior to initiating the study. Data regarding the patients were obtained from hospital records.

**Results:** The age group which was most affected was between 20- 40 years i.e.; the working population of the country. Most of the patients were of the male gender, nearly 70.3%. The sense organ to be affected the most in these incidents was ear(55.2%), followed by eyes(39.3%) . Facial scar caused a significant social impact on the quality of life among females.

**Conclusion:** This study aims to set a standard protocol in the post-critical phase in firearm injuries; giving priority to functions of sense organs and facial visage to ensure a good quality of life in the post-trauma period.

## Introduction

In this era of peace and stringent firearm regulatory norms, the civilian firearm injuries are rarely encountered in the day to day life. These injuries might be resulting from assault, accidental or suicidal attempts. Though these injuries are encountered on low frequency in day to day life. Being one of the vulnerable targets of terrorist attacks, we encounter these injuries in bits and pieces in mass causality involved in these attacks. This study aims to evaluate the long term effects of such firearm injuries on special senses and facial visage.

The firearm injuries are devastating, costing immense physical as well as psychological trauma to the patient. Bullet

injuries to head and neck region are often life threatening and demands an elaborate clinical examination and meticulous operative management due to the complexity of craniofacial anatomy.

It is important for the surgeon to understand the basic principles of terminal gunshot ballistics and the projectile's effect on striking tissue for the best management possible in these injuries. Ballistics is the study of the natural laws governing projectile missiles and the study of their predictable performances [1].

Ballistics include study of different types of firearm injuries like Rifled Firearms, Smooth-bore firearm (shot gun), Air or

gas operated firearm, Country made firearm and Blast injuries. Of all the five sense organs, ear is the most vulnerable and olfactory function is least affected [2]. In addition, gunshot injuries to anatomic structures within or contiguous to the temporal bone can also present challenging diagnostic and management problems [3]. Vision can be affected due to flames and other chemicals emitted from bullet apart from the direct trauma. In most cases, traumatic visual loss is related to direct ocular injury and occurs in the setting of severe head trauma associated with loss of consciousness. Less common is unilateral or bilateral visual loss with normal ocular appearance, suggesting trauma to the optic nerve or intracranial visual pathways, for which a neurologic or neurosurgical consultation is often requested [4].

Usually these injuries are encountered on a mass scale and a standardised protocol has not been drafted till date for thorough evaluation of its impact on the sense organs directly or indirectly.

No much study has been described in literature on the impact of firearm injuries with special thrust on sense organs and facial visage till date. With advancement in medical science, its high time that we follow a protocol following triage in these cases of firearm injuries, to ensure a better quality life in post trauma phase.

The main objective was to study the long term effects of firearm injuries on five senses and facial visage among patients affected in different firearm accidents encountered in Mumbai during the time frame of 1990 to 2018 at tertiary care centre, Grant Government Medical College and Sir JJ Group of Hospitals.

## Materials and Methods

This was a retrospective study of 532 patients who were victims of various firearm injuries in isolate incidents and terrorist attacks in Mumbai between January 1990 to July 2018 [5]. Institutional ethical clearance was obtained prior to initiating the study. Data regarding the patients were obtained from hospital records at Grant Government Medical College and Sir JJ Group of Hospitals.

Patients were traced; requested for follow up in ENT outpatient department by telephonic conversation. All patients were first subjected to a screening questionnaire recollecting the incident; the physical and mental trauma due to the incident was recorded. In case children below 12 years during the incident, questionnaire was filled by the guardian.

### Inclusion criteria included:

- 1) All patient of age and sex who had been victim in any kind of firearm injuries in the time period of January 1990 to July 2018 and who had been given primary care by the institute.
- 2) Patients who were referred to the institute from other parts of the country following firearm injury for further expert management

### Exclusion criteria:

- 1) Post mortem cases.
- 2) Patients who had intracranial and spinal injuries causing motor weakness [1].
- 3) Patients who had psychological impacts following incident like depression, post trauma stress disorder was excluded from the study.
- 4) Patients who were not willing for investigations and further follow up

The patients included in study following screening questionnaire was subjected to series of investigations for the following –

**Ear-** external examination of scar in pre auricular, post-auricular region, pinna, external auditory canal for any stenosis. Hearing assessment was done by tuning fork tests- Rinnes and Webers test using 256,512,1024 Hz tuning fork, PTA (pure tone audiogram ) in sound proof room by audiologist.

**Visual Examination** included external inspection of the eyes and periorbital region, measurement of visual acuity, pupillary examination, testing of extraocular movements, near vision using Snellens chart, slit lamp examination and fundoscopic examination.

### Olfactory- modified I smell chart

The odorants used in the study were modified according to local dietary and cultural habits. They were chosen based on the properties of pleasantness, familiarity and practicality. The substances were kept in opaque plastic bottles and patient's eyes were covered with black cloth when the substances were presented to them, to prevent any chance of visual identification. The cap was removed by the examiner for \*3 seconds, and the mouth of the bottle was placed \*2 cm in front of the nostril and patient was asked to sniff normally without any force. An interval of at least 30 s between successive presentations to prevent olfactory desensitization [6]. Patients were asked to choose from a list of four choices for each substance presented. Ten items were presented in random order for monorhinc smelling. To restrict the stimulus to one nostril, the participant was asked to hold the irrelevant nostril closed. The total odour identification score was calculated by adding the number of substances correctly identified. Substances used for odour identification were asafoetida (heeng), naphthalene balls (moth balls), garlic (lahsun), rose water, sandalwood oil, cardamom (elaichi), and clove oil (laung), lemon and cumin seeds (jeera).

**Facial scarring-** *To treat a scar or leave it alone depends on diagnosis of scar type and scar site, symptoms, severity, and stigma associated. A healed scar may leave with it varying degrees of functional and aesthetic impairment. The actual incidence is difficult to calculate. The standards of primary treatment is the best care resulting in minimum number and severity of facial scar [7]. The scar for some pose a social impact in the quality*

of life in the form of lack of confidence, social stigma. Despite improvements in burn care in the 20th century, scar especially in head and neck remains a problematic consequence and a factor that influences psychosocial adjustment in the recovery phase of victim [8].

All the above investigations results were collected and statistically analysed.

## Results

Based on data collected of 532 patients, they were compiled and analysed. Where applicable, we used an odds ratio (OR) and a 95 per cent confidence interval (CI) to compare results. Men were predominantly affected than females in these injuries in a ratio of 2:1 in bomblast injuries and gunshot injuries . Most of them belonged to the age group of 20- 40 years i.e.; working population of the country, constituting nearly 40.9 % of the total study population. Most of patients were of male gender, nearly 70.3%. The most common sense organ to be affected in these incidents was ear.

Ear was affected in 60.6 % males and 66.4% females affected in bomblast injuries ,in the form of conductive hearing loss in 48.8% ,sensorineural hearing loss in 20.1% and rest having mixed hearing loss. Bilateral involvement was encountered in nearly 85% who were victims of blast injuries. Unilateral hearing was affected in 55% of victims of bullet injuries (Table 1).

Eye was the second most affected in this study, affecting 39.7 % males and 35.1% females affected in bomblast injuries. Injuries were in the form of vision loss due to optic neuropathy, corneal scarring and retinal detachment of which optic neuropathy was the cause in 44.07% among those affected in bomb blast injuries and corneal scarring was the most common cause of vision loss among those who had gunshot injuries; 32.5% (Table 2).

Nose was affected in 22.1% males and 14.8% females who sustained bomb blast injuries ; 15.2% males and 12.7% females who sustained gunshot injuries

The type of injury was in the form of external scar and loss of olfaction. Loss of olfaction was the most common type of injury to nose in 66.2% of population affected by bomb blast injuries whereas among gunshot injuries .External deformity of nose was the most common affecting 76.9% of population affected by gunshot injuries (Table 3).

Facial scarring was highly variant in their location on face and the severity based on Vancouver grading, though in this study we assessed the social impact of the scars using the semi structured questionnaire. Facial scarring was noted in 39.4 % males and 44.5% affected in bomb blast injuries of which only 33.6% males and 68.4% females had social impact of the scar in the form of lack of confidence ,self-esteem .among population with gunshot injuries ,45.8% males and 40% females, of which 30.3% males and 66.6% females had social impact of scar (Table 4,5).

**Table 1:** Gender distribution and types of injury on hearing encountered in the study.

	Gender	Bomblast	Gunshot
Conductive Hearing Loss Chi Square=0.0125, Df=1 P=0.911	Male	92	15
	Female	39	6
Sensorineural Hearing Loss Chi Square=1.08, Df=1 P=0.297	Male	34	8
	Female	20	2
Mixed Hearing Loss Chi Square=0.122, Df=1 P=0.727	Male	48	5
	Female	22	3

**Table 2:** Gender distribution and types of visual injury encountered in the study.

	Gender	Vision Loss			Other(External Scarring, Ptosis, Restriction Of Extra Ocular Movements)
		Optic Neuritis	Corneal Scarring	Retinal Detachment	
Bomb Blast Chi Square=0.357, Df=1 P=0.837	Male	44	32	21	23
	Female	13	12	8	13
Gunshot Injuries Fischers Extract P=0.720	Male	7	10	5	6
	Female	5	4	2	4

**Table 3:** Gender distribution and types of injury of nose encountered in the study population.

Type Of Injury	Gender	Loss Of Olfaction	External Deformity
Bomb Blast Chi Square=2.76, Df=1 P=0.096	Male	45	15
	Female	12	8
Gunshot Fischers Extract P=1.00	Male	4	8
	Female	1	2

**Table 4:** Gender distribution in individuals who had impact as facial scarring.

	Bomb Blast	Gunshot
Male	119	33
Female	57	12

Chi Square=0.55, Df=1, P Value =0.46 With Or95% Ci=0.76(0.33-1.65).

**Table 5:** Gender distribution of facial scarring and social impact due to the injury in the study population.

Type Of Injury	Gender	Facial Scarring	Social Impact Of Scar*
Bomblast Chi Square=6.70, Df=1 P=0.01	Male	119	40
	Female	57	39
Gunshot Chi Square=1.88, Df=1 P=0.17	Male	33	10
	Female	12	8

Social impact of scar assessed by semi structured questionnaire.

## Discussion

Firearm injuries are not daily encountered in a peace promoting country like India. But as it's a vulnerable target of terrorist attacks, we rarely encounter these injuries in mass numbers especially as a tertiary care centre in Mumbai. Apart from these, occasional cases from other part of the country are often referred to our centre for expert management. In our

experience with these cases, complaints related to sense organs were not properly addressed during the primary care; probably due to lack of time/medical persons/standardised protocol to put focus on these complaints.

Men were predominantly affected than females in these injuries in a ratio of 2:1 in bomblast injuries as well as gunshot injuries. The age group most affected belonged to 20- 40 years i.e.; earning members of the country, constituting nearly 40.9 % of the total study population. similar to the result of S. Myint et al.,[9],Nasrulla et al.,[10], Fowler et al.,[11],This may be due to the male predominance in a gender biased society of a developing country like India, where male population are mostly assigned outdoor work .

The most vulnerable sense organ which was affected in these incidents was ear, in the form of bilateral conductive hearing loss similar to the results noted in Newton et al., [3], Conductive hearing loss could be attributed to the tympanic membrane perforations, ossicular disruption and external auditory canal stenosis Bilateral hearing loss in blast injuries can be attributed to the acoustic trauma caused to the ears. External deformity of pinna in the form of stenosis and scarring was also noted in nearly 30% population under study, of which most of them had gunshot injuries. Most of them resulted from the inadequate management of wound in external auditory canal during initial management.

Among the injuries to eyes, loss of vision was the most frequently encountered injury in nearly 39% population under study( 38% in bomb blast and 42% in gunshot injuries),comparable to the results in Shuttleworth GN et al.,[12], Optic neuritis was the cause of vision loss in majority of bomb blast injuries causing bilateral blindness in 60% of cases whereas corneal scarring was the most common cause of blindness in firearm injuries, causing unilateral blindness in 55% .Ocular injuries from blast injuries can be direct blast injuries due to the mechanical and thermal effects on eyelids/retina/globe. Radiation retinitis was quoted as a factor in blindness in blast injuries by Wong et al.,[13], We encountered in our centre, a case of firearm bullet lodged in left orbit, which was successfully removed endoscopically . An early meticulous evaluation and management resulted in improvement of vision in the form of perception of light in affected eye compared to earlier status of no perception of light (Figures 1,2).

Patient had perception of light after the endoscopic removal of bullet compared to nil perception of light prior.

Olfactory function assessment was the most sensitive test to assess residual brain dysfunction [14]. It may be due to the direct injury to nose, damaging cribriform plates and olfactory nerves or due to traumatic brain injury causing residual brain damage. As most of the patients who had severe brain injury like motor weakness were excluded from our study, among our study population, least number of people had olfactory dysfunction. Additional features such as smell threshold and discrimination ability were not assessed, which is a limitation in the study.

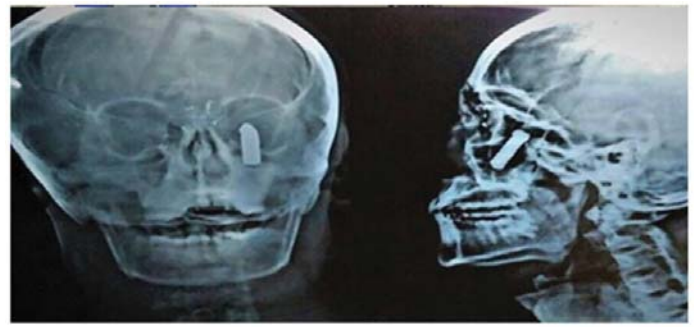


Figure 1: X-ray skull AP, Lateral view depicting foreign body (bullet) lodged in left orbital apex.



Figure 2: Per and post-endoscopic removal of the bullet lodged in the left orbit, a case of civilian firearm injury.

Social impact of scar was a significantly high in females affected in bomb blast and bullet injuries due to the aesthetic importance of face among females. Most of the firearm injuries were homicidal with head and neck region being the most common target [15]. Early definitive and comprehensive treatment of the facial injury in the first stage with minimal debridement has been shown to result in lower morbidity, faster return of function, shorter hospital [16].

## Conclusion

Patients sustaining firearm injuries to head and neck region end up in heavy tissue damage [17,18]. A lot of difference persists between management of firearm injuries among civilian and military population. The civilian trauma management is limited by chaotic nature of unexpected mass causality descending civilian medical system who lack a training in such injuries [2].

Most patients live with an external scar or an impairment of single or multiple sense organs causing a social impairment unrecognised on mass scale. All the 532 patients who were included in the study had some impact on their sense organs. This study aims to set in framing of a standard protocol giving priority to functions of sense organs following these injuries to ensure a good quality of life of victims in post trauma phase.

## Questionnaire and Proforma

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