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Research Article

A Clinical Study of Ocular Trauma: Etiology, Pattern, Management and Visual Outcome

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Abstract

Purpose: To understand the profile of ocular trauma presenting to a tertiary hospital in Rajasthan, India.

Study Design: Prospective, case-series study.

Methods: We included ocular injury patients attending Sahai Hospital and Research Centre. Questionnaires based on India Eye Injury Registry were used. Mechanical and chemical injuries were classified as per Ocular Trauma Classification Group (OTCG), and Ropar-Hall Classification, respectively.

Results: Of 405 patients (411 eyes), majority were male (77.9%). None of the patients was using eye protective device (EPD). The most commonly affected group was aged 21-30 years, farmers (25.3%), and rural patients (51.1%). More urban patients presented within 12 hours, 29.9% c. f. 6.2%. Presentation after 24 hours had poorer best corrected visual acuity (BCVA) ($p = 0.001$), and it declined with increasing interval ($p = 0.001$). Majority of injuries were mechanical (395, 96.1%) with hammer-chisel works (20.4%). Close-globe injury (CGI) out-numbered open globe injury (OGI) (306,74.4% c. f. 89, 21.6%). Contusion in CGI (52.9%), and penetrating injury in OGI (61.8%) were the most common types. Cornea was the most common tissue injured (69.6%) and corneal opacity the most common complication. In CGI, zone of injury was the single most important visual prognostic factor ($p = 0.001$). In OGI, type ($p = 0.002$), grades ($p = 0.004$), and zones ($p = 0.004$) of injury determined visual prognosis.

Conclusions: Patients presenting within 24 hours had good prognosis. In OGI, higher grade and more posterior entry site had poor prognosis. In CGI, zone was the only significant prognostic factor. Most of the injuries were avoidable. We recommend compulsory use of EPDs while on work.

Keywords: Eye Injury; Golden Hour; Mechanical Injury; Ocular Trauma; OTCG

Introduction

Ocular trauma is an important public health issue and one of the most common causes of preventable blindness and visual impairment [1]. Worldwide, approximately 1.6 million people are blind from ocular injuries, 2.3 million with bilateral and 19.0 million with unilateral visual loss [2]. Only 2.3% of injuries require hospitalization but noteworthy is that over 10% of them lose useful vision [3]. Despite anatomical and physiological protection, injuries to the eyes are common with poor prognosis due to vulnerable tissues, infection and meager amount of drug reaching ocular tissues [4].

Ocular injuries may be classified as mechanical and non-mechanical such as chemical, thermal, electrical, radiation-induced or ultrasonic [5]. National Eye Trauma System registry reports occupational injuries account for 22% of all penetrating injuries and among them construction work accounts for 42%, and hammer and chisel (H&C) being a major source [6]. Non-occupational eye injuries include domestic or recreational injuries [7]. In 1996 specific terminologies of ocular trauma were endorsed by the International Society of Ocular Trauma [8], and Ocular Trauma Classification Group (OTCG) was formed which proposed the standard classification of mechanical trauma [5].

Chemical injuries are potentially devastating resulting permanent visual impairment or blindness. Acids (except hydrofluoric acid) coagulate protein forming a protective coating of dead materials limiting the tissue damage. But alkali burn does not form such coating so the tissue damage extends deeper [9]. Burn frequently involves face with 20-30% incidence of eyelid involvement [10]. Ballen classified burns, which was later modified by Roper-Hall to provide prognostic guidelines based on corneal appearance and extent of limbal ischemia in 1965 [11].

The current study was conducted to report on the profile of ocular trauma cases presenting to a tertiary eye care centre in Rajasthan.

Methods and Patients

Study design and ethics

This prospective case series study was approved by the Sahai Hospital and Research Centre institutional review board and conducted with strict compliance to its guidelines. Informed written consent was given by all the participants. The identities of the participants were de-identified at the end of the study.

Setting

The study was conducted in a tertiary teaching Sahai Hospital and Research Centre, Jaipur, Rajasthan in India.

Patients

All the patients of ocular injuries presenting to the hospital and willing to participate for the study were included. The patients who received primary surgical intervention elsewhere, congenitally malformed eyes, preexisting ocular disease retarding visual outcome such as glaucoma, pathological myopia, amblyopia etc., and patients who had undergone intraocular surgery within 3 months in the study eye were excluded.

Ocular examination and data collection

Initial and final questionnaire forms which were developed based on the India Eye Injury Registry were used for the data collection. The initial form was used at first presentation to collect the demographic data, residential settings, occupation, injury report including use of eye protective devices (EPDs) during injury, medical history, systemic diseases and treatment history were noted. In cases of head injury, severe blunt injury or road traffic accident (RTA) relevant neurological examination was performed. Best corrected visual acuity (BCVA), and findings of anterior and posterior segments evaluation including tissues involved, location and extent of damage were noted. The X-ray orbit or skull, B-scan, CT or MRI scans were sought when indicated. Mechanical and chemical injuries were classified according to OTCG and Ropar-Hall classifications, respectively. The patients were followed up on day one, week one, month one and end of the third month. If patients received more than one surgical interventions the follow up was counted following the last intervention. During each follow up BCVA, wound healing, and early and late complications were recorded. Final questionnaire was used to record the details at the end of third month.

Statistics

Chi-Square test was applied to calculate p-values and confidence intervals.

Results

Demography

A total of 411 eyes of 405 patients were included. Age at presentation was 27.4 ± 15.4 years, ranging from 2 years to 80 years, mode and median age of 30 years and 25 years, respectively. It is noteworthy that in both the male and female groups, the most common age group affected was 21-30 years of age, which is the prime working age. Majority of patients were males (320, 77.9%) and from rural settings (51.1%). Details of age and sex distribution are shown in table 1.

Age group (years)	Male		Female		Total	
	n	%	n	%	n	%
0-10	47	14.7	14	15.4	61	14.8
11-20	71	22.2	11	12.1	82	20
21-30	109	34.1	22	24.2	131	31.9
31-40	52	16.3	19	20.9	71	17.3
41-50	23	7.2	16	17.6	39	9.5
>50	18	5.6	9	9.9	27	6.6
Total	320	100	91	100	411	100
n = number of eyes						

Table 1: Demographic characteristics of patients.

The farmer was the most common occupation affected (104, 25.3%), followed by laborer (99, 24.1%), student (89, 21.7%) and housewife (65, 15.8%). Other details are shown in table 2.

Occupation	Male		Female		Total	
	n	%	n	%	n	%
Farmer	98	30.6	6	6.6	104	25.3
Laborer	99	30.9	0	0	99	24.1
Student	72	22.5	17	18.7	89	21.7
Housewife	0	0	65	71.4	65	15.8
Business	35	10.9	0	0	35	8.5
Mechanic	9	2.8	0	0	9	2.2
Children	0	0	3	3.3	3	0.7
Others	7	2.2	0	0	7	1.7
Total	320	100	91	100	411	100
n = number of eyes						

Table 2: Occupation wise distribution.

Injury-presentation (i-p) intervals

We calculated the i-p intervals separately for the rural and urban patients. More urban patients presented earlier, for example, 105 patients (52.3%) from urban c. f. 41 patients (19.5%) from rural setting presented within 24 hours. Other details are shown in table 3.

Residential Status	i-p Time Interval	Male		Female		Total	
		n	%	n	%	n	%
Rural	<12 h	12	8.8	1	1.4	13	6.2
	12-24 h	20	14.7	8	10.8	28	13.3
	25-48 h	12	8.8	8	10.8	20	9.5
	49-72 h	10	7.4	2	2.7	12	5.7
	4-7 d	25	18.4	24	32.4	49	23.3
	8-30 d	33	24.3	21	28.4	54	25.7
	>30 d	24	17.7	10	13.5	34	16.2
	Total	136	100	74	100	210	100
Urban	<12 h	51	27.7	9	52.9	60	29.9
	12-24 h	42	22.8	3	17.7	45	22.4
	25-48 h	14	7.6	3	17.7	17	8.5
	49-72 h	20	10.9	0	0	20	10
	4-7 d	25	13.6	0	0	25	12.4
	8-30 d	18	9.8	1	5.9	19	9.5
	>30 d	14	7.6	1	5.9	15	7.5
	Total	184	100	17	100	201	7.5
i-p = injury-presentation, h = hours, d = days							

Table 3: Injury-presentation interval and residential status.

Noteworthy, none of the participants was using eye protective device (EPD) at the time of injury.

BCVA at presentation

Unfortunately, 147 eyes (35.8%) had BCVA of 6/60 or worse. Out of 146 patients presenting within 24 hours, 89 eyes (61.0%) had initial BCVA of 6/12 or better, while those presenting after 24 hours had poorer BCVA ($p = 0.001$ and CI = 0.414-0.511). As the i-p interval increased the initial BCVA declined ($p = 0.001$).

Sources of injury

H&C work was the most common source of injury (84, 20.4%), followed by wooden sticks (76, 18.5%), farming tools (34, 8.3%), crop plants (28, 6.8%), thorns (17, 4.1%), and grass (11, 2.7%). Finger-nail injury and manual fighting in 22 cases (5.4%), recreational accidents in 20 cases (4.9%), RTA and fall from height in 17 cases (4.1%), insect-related injury in 16 cases (3.9%), fire-crackers in 16 cases (3.9%), burn in 15 cases (3.6%), and animal-related injury in 10 patients (2.4%). Other causes in small number of cases included grinder, welding, garment hooks, household utensils and furniture.

Interestingly, all of the H&C, RTA, manual fighting, fall from height, grinder, and welding injuries involved male patients. The only sources of injury which involved more females than males were the finger nail and electricity related.

Tissues involved

The cornea was the most common tissue injured (286, 69.6%), followed by crystalline lens (91, 22.1%), conjunctiva (87, 21.2%), eyelids (56, 13.6%), vitreous (41, 10.0%) and retina (22, 5.4%). Other tissues involved were iris, sclera, angle structure, extraocular muscles, optic nerve, orbit and limbus.

Types of Injury

Mechanical injury was the most common type (395, 96.1%), followed by chemical (12, 2.9%), electrical (3, 0.7%) and thermal (1, 0.2%). Interestingly, 11 of 12 chemical injuries involved male. Other details of mechanical injuries based on OTCG specifications are shown in table 4.

Types of Injury	**OTCG classification of Injury**				**Total**
Open-globe injury	Penetrating	RIOFB	Rupture	Perforating	
Number of eyes	55	22	11	1	89
Percentage	61.8	24.7	12.5	1.1	100
Close- globe injury	Contusion	Lamellar laceration	Superficial FB	Mixed	Total
Number of eyes	162	57	85	2	306
Percentage	52.9	18.6	27.8	0.7	100

Table 4: Types of mechanical injury.

Open-globe injury (OGI)

- **Types of injury:** The details on types of OGI injuries are shown in Table 4. Globe rupture had poor BCVA at presentation: 2 had 6/18-6/36, 4 had CF-PL and one had NPL. Among 15 cases of RIOFB, 9 had BCVA of 6/12 or better, 5 had 6/18-6/36 and one had PL. The only case of perforating injury (entry and exit wounds) had only PL.
- **Grades of injury:** 3 of 3 eyes with grade-I injury, 3 of 4 eyes with grade-II injury and 20 of 53 eyes with grade-IV injury gained final BCVA of 6/12 or better, indicating higher the grade lower the prognosis.
- **Zones of injury:** 25 of 52 eyes with zone-I injury and 2 of 7 eyes with zone-II injury gained final BCVA of 6/12 or better, while 2 eyes with zone-III injury did not improve.

Close-globe injury (CGI)

- **Types of injury:** The details on types of CGI are shown in table 4.
- **Grades of injury:** We found lower the grades of injury better the final BCVA: 168 of 169 eyes (99.4%) with grade-I injury, 39 of 48 eyes (81.3%) with grade-II injury, 8 of 12 eyes (66.7%) with grade-III injury and 6 of 27 eyes (22.2%) with grade-IV injury gained final BCVA of 6/12 or better. An eye with grade-V injury did not improve.
- **Zones of injury:** Final visual outcome depended on the zone of injury significantly ($p = 0.001$): 211 of 233 eyes (90.6%) with zone-I injury, 5 of 7 eyes (71.4%) with zone-II injury and 5 of 17 eyes (29.4%) with zone-III injury gained final BCVA of 6/12 or better. Zone-III involvement showed very poor visual outcome ($p = 0.001$) but difference between zone-I and zone-II was not significant ($p = 1.000$). Among CGI, zone of injury was the single most important factor.

Treatments provided

The majority of patients needed only conservative treatment (207, 46.2%). Other common treatments were SFB removal (77, 17.2%), cataract operation (46, 10.3%), and primary wound repair (32, 7.1%). Other details are shown in table 5.

Primary Treatment	Male		Female		Total	
	n	%	n	%	n	%
Conservative	146	40.8	61	64.2	207	46.2
SFB Removal	75	21	2	2.1	77	17.2
Cataract Surgery	36	10.1	10	10.5	46	10.3
Wound Repair	28	7.8	4	4.2	32	7.1
Vitreous Surgery	20	5.6	3	3.2	18	4
RIOFB Removal	10	2.8	1	1.1	11	2.5
Retina Surgery	8	2.2	2	2.1	10	2.2
Excision	2	0.6	1	1.1	3	0.7
LAMA	33	9.2	11	11.6	44	9.8
Total	358	100	95	100	448	100
LAMA = Left Against Medical Advice, n = number of eyes						

Table 5: Primary treatments received by the patients.

Sixty-five cases of corneal abrasion presented within 24 hours, 18 of them healed without complication, 45 cases were healing on day 1, and 2 were status quo. Others presenting after 24 hours showed poor response to treatment and worsened (p = 0.001).

Of 38 patients with penetrating injury who completed 3 months follow up, 18 had BCVA of 6/12 or better (Table 6). Among OGI, penetrating injury had the best visual prognosis, followed by RIOFB removal. The final BCVA was better with RIOFB removal cases than globe rupture (p = 0.002) but no difference with penetrating injury (p = 1.000). Perforation and globe rupture showed very poor prognosis. The higher the grade of injury and more posterior the entry site the poorer was the prognosis (p = 0.004).

Type of Injury	Final BCVA					Total	
	6/12 or better	6/18-6/36	6/60-1/60	CF-PL	NPL	n	%
Penetrating	18	15	3	2	0	38	11.4
RIOFB	9	5	0	1	0	15	4.5
Rupture	0	2	0	4	1	7	2.1
Perforating	0	0	0	1	0	1	0.3
Total	27	22	3	8	1	61	18.3
%	8.1	6.6	0.9	2.4	0.3	18.3	
NB: total percentage is calculated out of 334 patients who completed final follow up.							

Table 6: Types of Open-Globe Injury and final BCVA.

In CGI prognosis wise, 108 of 131 eyes (82.4%) with contusion, 74 of 76 eyes (97.3%) with SFB, and 38 of 48 eyes (79.2%) with lamellar laceration gained final BCVA of 6/12 or better (Table 7). Among CGI, SFB removal had the best visual prognosis (p = 0.025).

Type of Injury	Final BCVA					Total	
	6/12 or better	6/18-6/36	6/60-1/60	CF-PL	NPL	n	%
Contusion	108	16	3	3	1	131	39.2
Superficial FB	74	2	0	0	0	76	22.7
Lamellar Laceration	38	9	1	0	0	48	14.4
Mixed	1	1	0	0	0	2	0.6
Total	221	28	4	3	1	257	76.9
%	66.2	8.4	1.2	0.9	0.3	76.9	
NB: total percentage is calculated out of 334 patients who completed final follow up.							

Table 7: Types of Close-Globe Injury and final BCVA.

Presentation within 24 hours of injury and initial BCVA were the main prognostic factors.

Complications and causes of poor visual outcome

CO was the most common early complication (124, 34.73%), followed by aphakia (19, 5.37%) and anterior chamber exudation or pupillary membrane (18, 5.04%). Other early complications included conjunctival and eyelid scars, secondary glaucoma, traumatic cataract, uveitis, hypotony, hyphema and traumatic mydriasis.

CO was the most common late complication (164, 49.10%), followed by aphakia (19, 5.69%), posterior capsular opacification (PCO) (9, 2.65%), and vitreous opacity (6, 1.8%). Other late complications were conjunctival and eyelid scars, macular degeneration, epiretinal membrane (ERM), optic atrophy, proliferative vitreoretinopathy (PVR) and retinal detachment (RD).

Discussion

Burden of preventable ocular trauma is borne by both patients and societies for so long and is increasing with population growth and urbanization [12]. In China alone, from 1990 to 2019, the number of people with moderate vision impairment increased by 133.67% (from 19.65 to 45.92 million), those with severe vision impairment increased by 147.14% (from 1.89 to 4.67 million), and those with blindness increased by 64.35% (from 5.29 to 8.69 million) [12]. Direct and indirect annual costs for these ocular injuries were estimated conservatively at $5 million and more importantly a loss of 60 work years in the USA [13], which has increased exponentially. The direct medical cost of admitted eye injuries per year in Australia alone in 2015 was extrapolated to almost $1,885 million [14].

The male preponderance (77.9%) in our study agreed with similar studies in the region [15-20], including in paediatric study [21]. Trauma while playing, working in the field and factories and leading active outdoor life may be responsible for the higher incidence among males. Age group of 21-30 years was the most common affected which is consistent with other studies on ocular trauma [15,22]. Similar to our finding, the working aged population are commonly afflicted by perforating eye injuries [23]. The age group is more actively involved in agricultural and construction work using H&C, grinder, welding and work more aggressively. We found that the farmer was the most common group inflicted, followed by laborer group, while other studies reported industry workers as the most common group [15,24]. Farming is the main occupation in Rajasthan, and stone quarry and masonry stone manufacturing are practiced at large scale in Rajasthan [25]. Therefore, these occupations constituted the groups affected maximally.

Less number of patients presented within 24 hours (35.5%) compared to another study (60.7%) [20] because in our study 51.1% were from rural areas which were challenged both geographically and economically to seek early medical care. Patients presenting within 24 hours had better BCVA at presentation than those presenting after 24 hours ($p = 0.001$), agreeing with another study [26]. Earlier the presentation the better was the BCVA at presentation as well as final visual prognosis. Presentation within 24 hours of injury and initial BCVA were the main prognostic factors both in OGI and CGI as agreed with another study [27]. It is advised to follow the golden hour rule, the first hour of injury, for treating or even making a referral in ocular injury or polytrauma patients who are at high risk for vision-threatening injuries [28].

The ocular injuries occur between 2.7 to 3.97% of eye diseases, of which mechanical injuries account for 94.25% [29]. We found that majority of injury was mechanical (96.1%). Maurya et. al. also reported 89.3% of injuries in northern India were mechanical [20]. Most of these mechanical injuries were minor with contusion and SFB lodged on the ocular surface or fornices and did not require hospitalization.

Most of the foreign bodies remain superficial as reported by other studies [30,31].

Some foreign bodies cause OGI with RIOFB, which are sometimes difficult to locate even with the help of imaging diagnostic methods [32], and even finding entry wound may be challenging [33].

H&C was the commonest source of injury (20.4%) because masonry stone manufacturing using H&C was very common in Rajasthan. In India, not only SFB, even RIOFB are commonly caused by hammering works [31]. A study conducted in 1960s reported H&C only the second most common source [30]. This might be a changing trend in the occupation and selection of work equipment.

The leading causes of eye injury are machinery or tools (21%), fights (18%), transport accidents (18%), and sports and training (11%). Only 7% were related to war and of these 90% were from non-battle activities [24].

Penetrating injury was the most common OGI (61.8%), similar to the report by another study [27], while older study reported perforating injury the most common injury [34]. Corneal abrasion presenting within 24 hours healed well, while those presenting after 24 hours showed poor response to treatment ($p = 0.001$), agreeing with other studies [22,31]. Animal *in vivo* study on mice has shown that in corneal scratch injury the pseudomonas invasion could occur only within 6 hours of scratch injury. By 6 hours, the previously exposed stroma was already completely covered by several layers of epithelial cells [35]. The clinical course of a corneal epithelial defect can range from a relatively benign self-healing abrasion to a potentially sight threatening complication such as a corneal ulcer, recurrent erosion, or traumatic iritis. Although the condition is treatable by primary physicians, the difficult cases are advised to be referred to the ophthalmologists [36].

Among the CGI we found the more posterior the zone of injury the poorer was the visual recovery. Blast injuries cause CGI due to shock waves and more posterior structures are involved resulting poor visual prognosis. It also causes OGI with bullets or pellets [37]. In OGI, the type of injury was the most important visual recovery determining factor. In particular the rupture is caused by blunt source and the mechanism is similar to blast trauma causing equatorial expansion and also damage more posterior structures due to shock waves resulting poor visual recovery [38].

Cornea was the commonest tissue involved (69.6%), which is consistent with other studies, because it occupies the greater area of an ellipse when eye is open. The eye is only 1:375 of the body surface area and only 0.10% of the erect frontal silhouette. However, the likelihood of severe ocular injuries is enhanced by various postures assumed during combat [39].

CO was the commonest complication because even minor injury like H&C injury and superficial corneal foreign body resulted CO. Aphakia was second commonest complications because implanting lens is challenging in traumatic eyes, and many cases were left aphakic after removal of traumatic cataract. Some surgeons prefer to implant intraocular lenses at a later date due to severe corneal injury or marked oedema, which may interfere with intraocular visualization, as secondary surgery when the eye is more stable [40].

The common causes of poor visual prognosis were CO, aphakia and traumatic cataract, which are also commonly attributed in other studies on ocular trauma [36,40]. Late presentation for medication resulting CO and high proportion of corneal injury with H&C were the reasons for CO being the most common complication and therefore, the most common cause for poor visual recovery too. High number of corneal pathology and the trauma as such made it difficult to perform intraocular lens implantation difficult forcing the surgeons to leave the cases aphakic. Culture and recreation related eye injuries happen frequently. Fireworks are used worldwide to celebrate religious and cultural festivals. The injuries caused by fireworks are more severe because of multiple mechanisms of injury - contact, flash, flame burns and injury secondary to blast shockwave force [41,42]. These injuries should be of more concerned because about 60% of such injuries occurred among the bystanders [42,43], 65.9% involve 18 years or younger patients [44], and 27.1% were bilateral [43].

At least 20.6% of eye trauma cases seek to traditional healer [45]. These patients present late to the hospital for proper management resulting complications and poor outcome. Seeking treatment from traditional healer is another concern which needs to be discouraged.

None of the patients was using EPDs during the injury. Most of the laborers were not aware of EPDs or even if they were aware of it, did not give importance to wearing it. A study on ocular trauma among rural population in southern India reported that 97.8% of patients with eye injury did not wear eye protection at the time of trauma [46]. Even in developed countries, the protective eye wear, especially in the regional areas, was not appreciatively high at 33.3% in Australia [47], and 21.7% in Singapore [48]. In the same Singaporean study, 43.7% of the patients were provided with the EPD but did not use them at the time of injury [48]. A study on occupational injury cases attending accidents and emergency department in UK found that 56% of the eye injury patients were not using EPD at the time of injury [49]. It is obvious that more workers in the developed countries use EPDs than in developing countries, but there is need to emphasize and encourage for the use of EPDs universally.

The study is limited by a short follow up period of three months only so could not study the long term complications, visual outcome and rehabilitation. Seventy-seven patients could not complete the final follow up which might have masked the value of final visual outcome and complications. Surgeries were done by different surgeons so the final visual outcome might have varied with difference in skills of the surgeons.

Conclusions

None of the patients was using EPDs during injury, many of them were not aware of EPDs and those who were aware did not give importance to wearing them. Using EPDs while working with H&C, grinding and lathe machines is utmost important. We need to propagate awareness regarding ocular trauma and associated complications, and protective values of EPDs. Parents be informed about the risks of firecrackers, blasting devices and sharp objects, and not letting their children play unsupervised. Following the rule of *Golden Hour* in trauma care be emphasized for timely referral and treatment. Counselling is important for understanding injury, treatment, prognosis and visual and vocational rehabilitations.

Conflict of Interest

Author BBR declares that he has no conflict of interest. Author AS declares that he has no conflict of interest. Author WG declares that she has no conflict of interest.

Author MS declares that she has no conflict of interest. Author TM declares that he has no conflict of interest.

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Ethical approval, Informed Consent and Consent for Publication

The study was approved by the Institutional Review Board (IRB) of Sahai Hospital and Research Centre, Jaipur, India, and was conducted as per the IRB guidelines and tenets of the Declaration of Helsinki. The informed consent was given by all the participants.

Availability of Data and Material

The data and material are available from the corresponding author.

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