

A COMPARATIVE ANALYSIS ON THE FREQUENCY, MANAGEMENT, AND PREVENTIVE MEASURES OF SODIUM HYPOCHLORITE ACCIDENTS DURING ROOT CANAL TREATMENT IN PUBLIC AND PRIVATE DENTAL INSTITUTIONS IN PUNJAB, PAKISTAN

Hammad Hassan¹, Imza Batool², Asma Shakoor³, Tabassum Awais⁴, Saba Ijaz⁵, Usman Ashraf⁶

¹Assistant Professor, Science of Dental Materials, Azra Naheed Dental College, Superior University, Lahore

²BDS, Dental Instructor, Institute of Advanced Dental Sciences & Research (IADSR), Lahore

³Associate Professor, Community & Preventive Dentistry Department, Institute of Dentistry, CMH, Lahore Medical

⁴Assistant Professor, Operative Dentistry Department, Avicenna Medical and Dental College, Lahore

⁵BDS Graduate, Sharif Medical and Dental College, Lahore

⁶Assistant Professor, Science of Dental Materials, Institute of Dentistry, CMH, Lahore Medical College, NUMS

Correspondence:

Dr. Hammad Hassan

Email:hammadhassanh@gmail.com

Abstract

Background: Sodium hypochlorite (NaOCl) is the irrigant of choice in endodontic therapy; however, extrusion beyond the apex can cause severe soft tissue injury causing complications in treatment.

Objective: To access the frequency of hypochlorite accidents, their management and preventive measures during root canal treatment in private and public dental institutes in Punjab, Pakistan..

Material and Methods: This cross-sectional study was conducted from Dec 22 to Aug24 in 2 private i.e., Azra Naheed Dental Hospital and University College of Dentistry and 1 public dental hospital i.e., de' Montmorency College of Dentistry. Dentists and house officers working in operative department participated by completing a validated 10-item online questionnaire developed and validated by the authors. Data was analyzed by using SPSS v24 using Chi square test.

Results: Out of 359 participants, 342 (95.3%) reported NaOCl accident at least once, with significantly higher frequency in private hospitals ($p=0.006$). There were 288 (69.9%) females and 124 (30.1%) males. The most common accident was extrusion beyond the apex ($n=120$, 35.2%), followed by soft tissue infiltration ($n=62$, 18.1%), and ingestion ($n=54$, 15.8%). Ingestion was more frequent in public hospitals ($p<0.001$). Pain ($n=292$, 85.7%), swelling ($n=234$, 68.4%), and erythematic ($n=260$, 75.9%) were more common in public hospitals. Preventive measures like low-concentration NaOCl was more practiced in public hospitals ($p=0.011$), while rubber dam ($p=0.024$) and side-vented needles ($p=0.003$) were more practiced in private hospitals.

Conclusion: NaOCl accidents were prevalent in Punjab, with notable differences in frequency, prevention, and management between sectors. Standardized protocols and targeted training are needed to improve patient safety.

Keywords: Accidents, Dentistry, Endodontic, Safety Management, Sodium Hypochlorite.

Cite this article: Hassan H, Batool I, Shakoor A, Awais T, Ijaz S, Ashraf U. A Comparative Analysis On The Frequency, Management, And Preventive Measures Of Sodium Hypochlorite Accidents During Root Canal Treatment In Public And Private Dental Institutions In Punjab, Pakistan. BMC J Med Sci. 2025; 6(2):67-72 <https://doi.org/10.70905/bmcj.06.02.0542>

Introduction:

Sodium hypochlorite (NaOCl) is commonly used in root canal irrigation due to its antimicrobial properties and effectiveness in dissolving organic tissues, however its accidental extrusion beyond the root canal apex can lead to soft tissue injury presenting challenges in clinical management and patient care.^{1,2}

The occurrence of NaOCl accidents during root canal treatment is comparatively low but varies across literature. A clinical study which involved 1123 teeth reported that 0.9% of the patients experienced acute pain due to NaOCl extrusion beyond apex with 60% of these cases exhibiting apical bleeding and swelling and emphasized that

Authorship Contribution: ^{1,6}Substantial contributions to the conception or design of the work; or the acquisition, Data analysis, Literature review, ²Drafting the work or revising it critically for important intellectual content, ^{3,4,6}Final approval of the version to be published, Topic Selection & Supervision

Funding Source: none

Conflict of Interest: none

Received:july,08, 2025

Accepted: oct,26, 2025

Published:Dec 30,12,2025

immediate negative aspiration and irrigation with distilled water could lessen the complications.^{2, 3} Another study evaluated NaOCl extrusion in 75 immature maxillary anterior teeth which were subjected to various irrigation techniques and indicated that while NaOCl extrusion occurred, certain newer methods like diode laser and ultrasonic irrigation reported lower extrusion rates.⁴

Effective and early management of NaOCl accidents is very significant in minimizing tissue damage and healing promotion. Immediate measures include negative aspiration to remove the irrigant from periapical tissues and irrigation with distilled water to dilute any extruded NaOCl.² Previous studies suggest that these initial steps can significantly reduce the severity of tissue reactions, whereas, further management involve calcium hydroxide dressings, administration of analgesics, antibiotics, and corticosteroids to control inflammation and prevent infection.^{3, 5} The incorporation of low-level laser therapy has been proposed as an adjunctive treatment to improve healing in cases of NaOCl-induced tissue damage.⁶

The awareness and preparedness of dental practitioners play a key role in preventing and managing NaOCl accidents. A study assessing the knowledge of dentists regarding hypochlorite emergencies reported that a significant number were aware of the potential complications of NaOCl, there was variability in willingness to handle such incidents effectively, highlighted the need for standardized training and continuous education in form of workshops to improve preparedness in case of accidents and complications.⁷

The previous literature has mostly focused on causes and management of hypo accidents without comparing different types of dental institutions, however, there is limited regional data regarding NaOCl accidents in dental institutions in Punjab, as well as comparison of private and public dental institutes.⁷ Understanding the factors contributing to these incidents in both private and public sectors is essential for developing targeted preventive measures focusing each sector. Research involving this demographic is limited, underscoring the need for studies that evaluate the frequency, causes, and management outcomes of NaOCl accidents especially in this region.

The study aimed to access the frequency of hypochlorite accidents, their management and preventive measures during root canal treatment in private and public dental institutes in Punjab, Pakistan.

Material and Method:

Study design:

This questionnaire based descriptive cross sectional study was conducted after the approval of Institutional Review Board of the University College of Medicine and Dentistry, University of Lahore (No: UCD/ERCA/21/10asd) and participating institutes. The primary outcome was the frequency of hypochlorite accidents; secondary outcomes involved management strategies. Independent variables included demographic characteristics and hospital type (private vs public).

Study Setting and Duration:

The study was conducted from December 2022 to August 2024 in two private i.e., Azra Naheed Dental Hospital and University College of Medicine and Dentistry, Lahore and one public dental hospital i.e., de' Montmorency College of Dentistry. These institutions were selected due to their high patient flow, active endodontic departments for a meaningful comparison of resources, training levels, and safety protocols between two settings.

Sample Size and Sampling Technique:

The study participants were included using the convenience sampling technique. A total sample of 359 was calculated using 90% power at a 5% significance level, assuming an expected prevalence of 63%.

Inclusion Criteria:

The study was performed on dental surgeons and house officers working in operative & endodontic dental clinics who agreed to be the part of the study.

Exclusion Criteria:

The dentists and house officers working in any other department, did not have any experience in the operative & endodontic department, and did not give consent to be the part of the study were excluded

Questionnaire Development:

The questionnaire was developed by the authors after extensive literature review and consisted of 10 items involving demographic details and frequency and management of hypochlorite accidents during endodontic treatment. The questionnaire was validated (content and face validity) by the two research experts, one from operative & endodontic department and the other from community dentistry department and the modifications were made based on their recommendations. The questionnaire was pilot tested on 30 participants, which were not part of the final sample, afterwards their responses were assessed and minor revisions were made to improve consistency and interpretation. The reliability analysis was done using Cronbach's-alpha analysis test, with a score of 0.681, falling

within the acceptable limit. The final modifications were made accordingly.

Data Collection:

The study employed online questionnaires using Google Forms (Google Inc.) to assess the frequency and management of hypochlorite accidents during endodontic treatment. The questionnaires were distributed via Whatsapp groups of the operative departments. A focal person from each department was contacted for data collection who ensured distribution of questionnaire in the groups and repeated reminders for better response rate.

Statistical Analysis:

The data was analyzed using Statistical Package of Social Sciences (SPSS) (IBM, Corporation Version 24). Frequencies and percentages were expressed using descriptive statistics. The frequencies were compared using the Chi Square test i.e., the private and public dental hospitals, the frequency or type of NaOCl accident, as well as differences in preventive and management practices. A p-value ≤ 0.05 was considered statistically significant.

Results:

The study investigated the frequency of sodium hypochlorite (NaOCl) accidents during root canal treatments and the management strategies in both private and public dental institutions in Punjab, Pakistan. A total of 359 dental surgeons participated in the study, with 69.9% females (n = 288) and 30.1% males (n = 124). The sample included participants from both public (n = 150) and private (n = 262) dental hospitals. Most participants (43.7%) had 2 to 5 years of experience, followed by those with 5 to 10 years (34.5%), and more than 10 years (21.8%).

The study found that 342 participants (95.3%) reported experiencing at least one hypochlorite accident. Private dental institutions had a significantly higher frequency of accidents (p = 0.006). The type of accidents reported is provided in the table 1.

Type of Accident	Total (n=342)	Public (n=150)	Private (n=262)	X ²	p
Ingestion	54 (15.8%)	32 (21.3%)	22 (8.4%)	14.01	<0.001
Soft tissue infiltration	62 (18.1%)	24 (16.0%)	38 (14.5%)	0.167	0.671
Extrusion beyond apex	120 (35.2%)	46 (30.7%)	74 (28.2%)	0.271	0.603
Splatter in eyes	36 (10.5%)	8 (5.3%)	28 (10.7%)	3.42	0.064

The symptoms experienced during hypochlorite accidents were analyzed for both public and private sector participants. Statistically significant differences were observed in the frequency of pain, swelling, erythema, hemorrhage, and paresthesia as exhibited in table 2.

Symptoms	Total (n=342)	Public (n=150)	Private (n=262)	X ²	p
Pain	292 (85.7%)	116 (77.3%)	176 (67.2%)	4.76	0.029
Swelling	234 (68.4%)	94 (62.7%)	140 (53.5%)	3.31	0.043
Erythema	260 (75.9%)	84 (56.0%)	176 (67.2%)	5.11	0.016
Allergic reaction	140 (40.9%)	44 (29.3%)	96 (36.6%)	2.27	0.080
Bruising	146 (42.7%)	58 (38.7%)	88 (33.6%)	1.07	0.176
Hemorrhage	106 (31.0%)	30 (20.0%)	76 (29.0%)	4.05	0.047
Paresthesia	42 (12.3%)	22 (14.7%)	20 (7.6%)	5.15	0.028
Infection	12 (3.5%)	8 (5.3%)	4 (1.5%)	4.88	0.035

Preventive measures taken and their comparison between private and public institutes is shown in table 3. Low concentration NaOCl was used more frequently in the public sector (59.6%, p = 0.011). Rubber dams (64.3%) and side-vented needles (62.7%) were more commonly used in private institutions (p = 0.024 and p = 0.003, respectively).

Preventive Measures	Total (n=342)	Public (n=150)	Private (n=262)	X ²	p
Low concentration	204 (59.6%)	86 (57.3%)	118 (45.0%)	5.76	0.011
Use of rubber dam	220 (64.3%)	70 (46.7%)	150 (57.3%)	4.29	0.024
Use of side vented needle	214 (62.7%)	64 (42.7%)	150 (57.3%)	8.12	0.003
2mm above apex	224 (65.5%)	80 (53.3%)	144 (55.0%)	0.102	0.749
Low pressure	218 (63.8%)	76 (50.7%)	142 (54.2%)	0.478	0.490
Use of face shields	114 (33.4%)	38 (25.3%)	76 (29.0%)	0.643	0.422

Ocular irrigation was the most commonly reported management step for splashes in the eyes, with a significantly higher frequency of this measure taken in private institutions (p < 0.001). For accidental ingestion, follow-up was the most common management practice, but referral to the emergency department was more prevalent in private institutions (Table 4).

Table 4: Management Strategies for Accidental Splash in Eyes and Ingestion during Root Canal Treatment:					
Variables	n(%)	Public (n=150)	Private (n=262)	X²	p
Accidental Splash in Eyes					
Ocular irrigation	360(100%)	122(81.3%)	238(90.8%)	25.44	<0.001
Refer to ophthalmologist	38(10.5%)	14(9.3%)	24(9.2%)		
Pain killers	8(2.2%)	8(5.3%)	0(0%)		
Urgent administration of IV steroids and antibiotics	6(1.7%)	6(4.0%)	0(0%)		
Accidental Ingestion					
Follow-up of patient	154(45.1%)	56(37.3%)	98(37.4%)	4.88	0.180
Refer to the emergency department	200(58.5%)	66(44.0%)	134(51.2%)		
Refer to gastroenterologist	48(14.0%)	24(16.0%)	24(9.2%)		
Urgent administration of IV steroids and antibiotics	10(2.9%)	4(2.7%)	6(2.3%)		

Discussion:

The study found that 342 out of 359 respondents reported experiencing sodium hypochlorite (NaOCl) accident during root canal treatments at least once during their career practice. Private dental institutions had a significantly higher frequency of such accidents ($p = 0.006$). These findings are consistent with previous literature, which suggests that NaOCl accidents, although relatively rare, occur in a significant number of cases, particularly in settings where the frequency of root canal treatments is higher or other factors like experienced operator and use of concentrated hypochlorite.⁸⁻¹¹ Kleier et al., in a study of diplomats from the American Board of Endodontic reported that 132 out of 314 surveyed endodontists reported experiencing a sodium hypochlorite accident, suggesting a notable but uncommon occurrence.¹² Previous studies have reported that NaOCl accidents occur in about 10-21% of cases, which is not consistent with the occurrence in this study.^{5, 13-15} However, the high rate of accidents in private institutions in this study may reflect the higher volume of root canal treatments and may also attributes to the differences in the availability of safety protocols, training level, reporting of endodontic mishaps or equipment.

The current study identified four main types of NaOCl accidents: ingestion, soft tissue infiltration, extrusion beyond

apex, and splatter in eyes. Infiltration beyond apex, commonly due to improper irrigation was the most common occurrence and was in congruence with the previous literature.^{10, 16} This extrusion beyond apex can lead to severe tissue reactions that can follow including soft tissue damage and bone necrosis.¹⁷ Proper techniques, such as using side-vented needles and stopping short of the working length, are crucial to prevent such accidents.¹⁸ Accidental ingestion was the most frequently reported accident in public settings ($p < 0.001$). Inadvertent ingestion is a common concern in the literature and can lead to serious complications.^{19, 20} A study by Gamal-AbdelNaser., reported ingestion in about 20% of NaOCl accidents.¹⁸ The difference in the frequency of accidents between the public and private sectors may reflect differences in clinical practices, supervision, funding and the experience levels of the dental professionals involved.

In the study, pain, swelling, and erythema were the most commonly reported symptoms associated with NaOCl accidents, with significantly higher frequencies observed in private institutions. These results are consistent with previous studies, where pain and swelling are commonly reported following NaOCl accidents due to the cytotoxic nature of NaOCl.^{3, 7} A study by Kartit et al., also observed pain as the most frequent symptom, followed by swelling and ecchymosis.²¹ The higher incidence of these symptoms in private institutions in this study may be attributed to differences in patient population, more efficient reporting and documentation of accidents, use of more concentrated hypochlorite, or the severity of the accidents. Private dental institutions in Punjab, Pakistan, are better equipped, with more funding, and have robust patient documentation and follow-up procedures in the event of mishaps.¹⁵ The public sector face limited funding, lesser reporting and in adequate follow-up, which may explain the lower frequency of accidents reported in that sector. These incidents could remain unreported or underreported due to the high patient flow and limited resources.^{14, 15, 22}

Regarding preventive measures, the current study reported that low concentration NaOCl was more frequently used in the public sector hospitals ($p = 0.011$), whereas, the rubber dams (64.3%) and side-vented needles (62.7%) were more commonly utilized in private hospitals. These findings indicate the variations in safety practices between public and private dental institutions.¹⁵ The use of rubber dams and side-vented needles in private institutions could be due to better access to modern equipment, better funding as

well as better patient safety in private hospitals.²² Low concentration NaOCl was frequently used in the public sector, which may indicate cost-saving measures or altered institutional guidelines regarding the dilution of NaOCl.²³ Previous studies have underscored the importance of rubber dam to isolate the tooth and prevent the accidental extrusion, as well as the use of side-vented needles to reduce the risk of extrusion beyond the apex.^{7, 24, 25}

The current study reported ocular irrigation as one of the most common management for eye splash with significantly higher frequencies in private institutions ($p < 0.001$). Regarding accidental ingestion, follow-up was the most common management; however, referral to the emergency department was more prevalent in private institutions. These findings are consistent with the global literature, which recommends immediate ocular irrigation and referral to an ophthalmologist in cases of eye splashes, and close monitoring, follow-up and referral to emergency for patients who accidentally ingest NaOCl.^{19, 26} In cases of splash in eyes, previous studies have recommended ocular irrigation and the use of steroids and antibiotics in severe cases of NaOCl accidents.^{18, 27} The differences in management practices between public and private institutions may reflect differences in resources, training, and access to specialized care.

Conclusion:

Study reported a higher frequency of NaOCl accidents in private dental institutions likely due to better reporting, documentation, and available resources. Public institutions reported fewer accidents, possibly due to underreporting or lack of follow-up, due to limited resources and high patient volume. The study also highlighted differences in NaOCl concentrations and symptoms with private institutions reporting more severe outcomes. Preventive measures such as rubber dam and side-vented needles were more commonly used in private settings. The findings underscore the need for improved reporting systems and enhanced safety protocols in public institutions and the development of specific guidelines and training to enhance patient safety and quality of care in both private and public dental hospitals.

Acknowledgements

None to declare.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical Approval

The study was approved by the Institutional Review Board of the University College of Medicine and Dentistry, University of Lahore (Reference No: UCD/ERCA/21/10asd).

Consent for Publication

All authors have reviewed and approved the final manuscript and consent to its publication.

Consent to Participate

Informed consent was obtained from all individual participants included in the study.

Conflict of Interest

The authors declare that they have no conflict of interest related to this study.

Competing Interests/Funding

The authors declare no competing interests. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References:

1. Drews DJ, Nguyen AD, Diederich A, Gernhardt CR. The interaction of two widely used endodontic irrigants, chlorhexidine and sodium hypochlorite, and its impact on the disinfection protocol during root canal treatment. *Antibiotics*. 2023 Mar 16;12(3):589.
2. Özdemir O, Hazar E, Koçak S, Sağlam BC, Koçak MM. The frequency of sodium hypochlorite extrusion during root canal treatment: an observational clinical study. *Australian Dental Journal*. 2022 Mar;67:S57-64.
3. Nasiri K, Wrbas KT. Management of sodium hypochlorite accident in root canal treatment. *Journal of Dental Sciences*. 2023 Feb 2;18(2):945.
4. Karasu AE, Goker Kamalı S, Turkyayın D. Comparison of apical extrusion of sodium hypochlorite in immature teeth after needle irrigation, ultrasonic irrigation, EDDY, Er: YAG, and diode lasers. *Lasers in Medical Science*. 2022 Dec 21;38(1):8.
5. Kanagasalingam S, Blum IR. Sodium hypochlorite extrusion accidents: management and medico-legal considerations. *Primary Dental Journal*. 2020 Dec;9(4):59-63.
6. Soares BP, da Silva Filho JE, Dias AA. Low Intensity Laser Therapy: A Review of Its Applications and Effectiveness in Health, General Dentistry and Endodontics. *Archives of Current Research International*. 2024 Oct 1;24(10):16-27.
7. Riaz S, Hassan H, Naz S, Iqbal K, Haider I, Sajjad M. Knowledge and Awareness of Dentists about Hypochlorite Emergencies and their Management during Endodontic Treatment. *Annals of Punjab Medical College*. 2024 Dec 31;18(4):278-83.
8. Mustafa M, Almuhaiza M, Alamri HM, Abdulwahed A, Alghomlas ZI, Alothman TA, Alhajri FF. Evaluation of the causes of failure of root canal treatment among patients in the City of Al-Kharj, Saudi Arabia. *Nigerian Journal of Clinical Practice*. 2021 Apr 1;24(4):621-8.
9. Psimma Z, Boutsoukis C. A critical view on sodium hypochlorite accidents. *Endodontic Practice Today*. 2019 Jun 1;13(2).
10. Pai AV. Factors influencing the occurrence and progress of sodium hypochlorite accident: A narrative and update review. *Journal of Conservative Dentistry and Endodontics*. 2023 Jan 1;26(1):3-11.
11. Kucur A, Pirmoglu B, Keskin C. Evaluation of the knowledge levels of dentistry undergraduate students regarding sodium hypochlorite accidents and management. *Turkish Endodontic Journal (TEJ)*.;10(1):50-5.
12. Kleier DJ, Averbach RE, Mehdipour O. The sodium hypochlorite accident: experience of diplomates of the American Board of Endodontics. *Journal of Endodontics*. 2008 Nov 1;34(11):1346-50.
13. Osegueda-Espinosa AA, Sánchez-Pérez L, Perea-Pérez B, Labajo-González E, Acosta-Gio AE. Dentists survey on adverse events during their clinical training. *Journal of Patient Safety*. 2020 Dec 1;16(4):e240-4.

14. Hassan H, Ali SM, Chaudhry AA, Riaz S, Khawar B, Aziz S. Endodontic procedural errors and their reporting and referral among dental graduates working at dental institutes in Punjab: a cross-sectional study. *Khyber Medical University Journal*. 2023 Jun 30;15(2):96-100.
15. Hassan H, Ali SM, Riaz S, Aziz S, Saleem MN, Raja HZ. Prevalence of endodontic mishaps and their management in private and public dental institutes in Punjab, Pakistan. *Rawal Med J*. 2023 Apr;48(2):468-72.
16. KHANDELWAL P, HAJIRA N. Worrisome Implications of Accidental Injection of Colourless Corrosive Chemicals Intraorally into Perioral Tissue Spaces: A Severe Negligence. *Journal of Clinical & Diagnostic Research*. 2022 May 1;16(5).
17. Fiorillo L, D'Amico C, Meto A, Mehta V, Giudice GL, Cervino G. Sodium hypochlorite accidents in endodontic practice: Clinical evidence and state of the art. *Journal of Craniofacial Surgery*. 2024 Oct 1;35(7):e636-45.
18. Gamal-AbdelNaser A, Elnaggar A, Mekawy M, Boshra G, Ghareeb N. Sodium hypochlorite accident—complications, management and potential prevention: a report of three cases. *Frontiers of Oral and Maxillofacial Medicine*. 2025 Jun 10;7.
19. Chung I, Ryu H, Yoon SY, Ha JC. Health effects of sodium hypochlorite: review of published case reports. *Environmental Analysis, Health and Toxicology*. 2022 Mar 30;37(1):e2022006.
20. Hegde A, Shetty P, Bhat R. Insight on the use and abuse of sodium hypochlorite in endodontics: a review. *International Journal of Dentistry and Oral Science*. 2021 Aug 19;8(8):4028-31.
21. Kartit Z, Delacroix C, Clement C, Beurrier M, Mouton-Faivre C, Petitpain N. Sodium hypochlorite accident diagnosis and management: Analysis from the literature and the French pharmacovigilance database. *Fundamental & Clinical Pharmacology*. 2024 Aug;38(4):630-9.
22. Ameer MI. Analysis of reporting system for procedural errors in the endodontics departments of dental institutes of Punjab. *Biomedica*. 2023 Jun 1;39(2).
23. Rahman AE, Ruslan NH, Zamaili AN. Reduction of Flare-up in Root Canal Treatment: An Improved Treatment. *Q Bulletin*. 2021 Nov 12;1(30):4-17.
24. Salvadori M, Venturi G, Bertolotti P, Francinelli J, Tonini R, Garo ML, Salgarello S. Sodium hypochlorite accident during canal treatment: report of four cases documented according to new standards. *Applied Sciences*. 2022 Aug 26;12(17):8525.
25. Jain PR, De Lemos AN. Legal Considerations in Endodontics. In: *Common Complications in Endodontics: Prevention and Management* 2025 Mar 19 (pp. 321-349). Cham: Springer Nature Switzerland.
26. Chou HD, Chen KJ, Kang EY, Lin JY, Yeh PH, Chen YT, Cheng CT, Lai CC, Wu WC, Hwang YS, Hsiao CH. Eye irrigation as a first-line treatment and diagnostic method for emergency department patients who complain of ocular foreign bodies. *Scientific Reports*. 2021 Dec 3;11(1):23386.
27. Liu C, Qureshi S, Armstrong GW. Chemical Corneal Injuries. In: *Cornea Casebook* 2025 Mar 7 (pp. 337-351). Singapore: Springer Nature Singapore.