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Application and Effectiveness Evaluation of Standardized Protective Care Procedures in Hydrofluoric Acid Operations within Dental Departments

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Abstract: *Objective*: To evaluate the implementation effectiveness of standardized protective care procedures during hydrofluoric acid procedures in the dental department. *Methods*: This study was conducted from June 2023 to June 2025, selecting 90 patients who underwent hydrofluoric acid-related treatments in the outpatient dental department of this hospital during this period as subjects. Forty-five patients treated between June 2023 and June 2024 received conventional protective care (pre-intervention group), while 45 patients treated between June 2024 and June 2025 underwent the standardized protective care protocol (post-intervention group). Thirteen healthcare personnel participated in both pre- and post-intervention treatment phases. Based on the different nursing models, indicators such as the incidence of adverse events in patients and the exposure rate of healthcare personnel before and after implementation were compared to evaluate the effectiveness of the nursing intervention. *Results:* The incidence of oral mucosal irritation reactions in patients was lower after implementation, $p < 0.05$. Compared with the pre-implementation period, the incidence of procedure-related adverse events decreased after implementation, $p < 0.05$. There was a significant difference in the occupational exposure rate of healthcare personnel before and after implementation, with a higher rate observed before implementation ($p < 0.05$). Post-implementation, healthcare personnel achieved higher compliance scores for pre-procedure preparation, intra-procedure protection, and post-procedure handling ($p < 0.05$). Patient satisfaction with treatment was lower pre-implementation than post-implementation ($p < 0.05$). *Conclusion:* Adherence to standardized protective care procedures during hydrofluoric acid operations by dental department staff in outpatient settings standardizes practitioner techniques, effectively prevents oral mucosal irritation in patients, reduces occupational exposure risks for staff, minimizes adverse procedural events, and consequently enhances patient treatment satisfaction. This demonstrates significant practical value.

Keywords: Standardized protective care procedures; Dental department; Outpatient clinic; Hydrofluoric acid handling

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1. Introduction

In clinical dentistry, hydrofluoric acid is frequently employed during therapeutic procedures such as inlay restoration to perform efficient acid etching. This process ensures robust bonding between porcelain inlays and soft tissues, facilitating subsequent treatment steps and guaranteeing restorative outcomes. However, hydrofluoric acid is an inorganic acid with exceptionally high reactivity, exhibiting strong corrosiveness and high permeability. Inadequate protective measures during handling may lead to occupational exposure, such as skin contact, resulting in chemical burns, respiratory tract damage, or oral mucosal irritation in patients [1,2]. Consequently, effective protective measures are essential during hydrofluoric acid procedures in dentistry to mitigate safety risks and safeguard the health of both healthcare personnel and patients. This study aims to establish a standardized protective nursing protocol for comprehensive management throughout the entire hydrofluoric acid procedure, evaluating its application efficacy. The findings are reported as follows.

2. Materials and methods

2.1. General information

This study involved 90 patients undergoing hydrofluoric acid-related treatment, all of whom attended the outpatient dental department of our hospital between June 2023 and June 2025. Protective nursing measures were implemented according to the sequence of their appointments. The conventional care group (pre-implementation) comprised 24 males and 21 females, aged 20–68 years (mean 43.27 ± 3.62). The standardized protective care group (post-implementation) included 25 males and 20 females, with ages ranging from 20 to 69 years (mean 43.51 ± 3.70 years). Thirteen healthcare personnel participated in both groups: five physicians and eight nurses, aged 24 to 45 years (mean 32.51 ± 3.47 years). Baseline data showed no significant differences before and after implementation ($p > 0.05$), indicating comparability.

2.1.1. Inclusion criteria

(1) All subjects must undergo hydrofluoric acid treatment;
(2) Subjects must be conscious and able to cooperate with treatment and nursing care;
(3) Subjects must provide informed consent to participate in the study.

2.1.2. Exclusion criteria

(1) Concurrent oral mucosal lesions;
(2) Severe hepatic or renal impairment;
(3) Hypersensitivity to hydrofluoric acid therapy.

2.2. Methodology

Between January and December 2023, routine protective care was implemented for 45 patients undergoing treatment. Prior to procedures, nursing staff briefed patients on precautions for hydrofluoric acid handling while wearing masks, gloves, and protective gowns. During operations, protective measures were applied based on established protocols. Post-procedure, the treatment area was thoroughly cleaned, and all used instruments were disinfected.

Between January and December 2024, a standardized protective nursing protocol was established for the

treatment of 45 patients, with nursing duties conducted accordingly.

(1) Standardized protective nursing team

Led by the Head Nurse, a standardized protective nursing team was formed comprising dentists, nurses and other relevant personnel. This team developed a standardized protective nursing protocol based on applicable operational safety guidelines and protocols. All healthcare personnel were required to undergo systematic training and pass an assessment before being permitted to participate in nursing duties [3].

(2) Pre procedure preparation

During pre-procedure preparation, all healthcare personnel underwent joint training covering hydrofluoric acid hazards, protective protocols, and emergency response measures, with participation in treatment nursing contingent upon passing assessments. Nursing staff conducted comprehensive patient assessments based on prior allergy history, oral condition, and general health status to formulate individualized protective plans [4]. Patients and their families are informed about hydrofluoric acid procedures in plain language, emphasizing potential risks and protective measures to enhance compliance. Protective equipment such as acid-resistant gloves, goggles, and protective face shields is prepared according to operational standards. Hydrofluoric acid reagents are inspected for expiry dates and packaging integrity to prevent leakage. Prepare emergency supplies for hydrofluoric acid exposure, such as calcium gluconate gel and physiological saline [5]. Affix hydrofluoric acid warning signs in the operational area, clear away unrelated items, arrange necessary reagents and instruments appropriately, and strictly demarcate contaminated and clean zones to prevent cross-contamination. Activate ventilation equipment in the operating room to maintain adequate airflow.

(3) Implement protective measures during procedures

Healthcare personnel must correctly wear acid-resistant masks, aprons, and nitrile gloves to ensure comprehensive protection. Strictly adhere to protocol requirements, controlling HF dosage and concentration to prevent overuse. Establish dedicated splash-proof zones on treatment tables with acid-resistant mats. Implement personalized patient protection by applying petroleum jelly around the oral cavity. Use a saliva ejector to promptly remove vapors and waste liquid generated during the procedure, minimizing irritation [6]. Healthcare personnel should inspect the integrity of protective equipment seals every 5 minutes. Should reagent leakage occur, cease operations immediately. Clean up using specialized absorbent materials and flush contaminated areas with copious amounts of water. Upon completion of acid etching, immediately rinse the porcelain inlay and surrounding area three times with physiological saline solution. Collect the rinsing solution in dedicated corrosion-resistant containers.

(4) Post-procedure management

After completion, rinse the patient's oral cavity with physiological saline to ensure no residual hydrofluoric acid remains. Inspect the oral mucosa for burns or other abnormalities, treating any findings with oral ulcer ointment. Seal any residual hydrofluoric acid reagent and store it in a dedicated corrosion-resistant cabinet. Wipe the operating area clean with water, then disinfect it by spraying with a chlorine-based disinfectant. After half an hour, wipe again with water. Immerse used etching instruments in a 5% calcium hydroxide solution for 40 minutes to neutralize them, then dispose of them according to medical waste regulations. Medical staff shall remove protective equipment in the prescribed sequence and disinfect hands using a quick-drying hand sanitizer [7]. Advise patients to avoid consuming spicy, hot, or hard foods for 2 hours post-procedure, maintain oral hygiene, and return promptly for review should any discomfort arise.

2.3. Observation indicators

2.3.1. Assessment of patient mucosal irritation

Observe and record patients' oral mucosal irritation reactions, such as pain, redness, swelling, and burns, following hydrofluoric acid procedures, comparing incidence rates before and after implementation.

2.3.2. Assessment of operational safety incidents

Adverse events occurring during statistical operations, including hydrofluoric acid leaks, accidental patient injuries, and reagent misuse, shall be compared in terms of their incidence rates.

2.3.3. Assessment of healthcare staff exposure rates

Record instances of respiratory inhalation, skin and eye contact occurring during hydrofluoric acid handling by healthcare personnel before and after implementation, and compare occupational exposure rates.

2.3.4. Assessment of personal protective equipment compliance

Assessment of compliance with protective procedures for healthcare personnel, evaluating the standard of practice in donning protective equipment prior to procedures, implementation of protective measures during procedures, and post-procedure handling. Scored out of 100 points, with higher scores indicating greater compliance.

2.4. Statistical analysis

Data obtained in this study are presented as (n, %). Count data conforming to normal distribution are expressed as (n, %). All data were entered into SPSS 23.0 software. Following categorization, *t*-tests (for continuous data) and chi-square tests (for categorical data) were conducted. Differences were assessed based on *p*-values, with $p < 0.05$ indicating statistically significant differences.

3. Results

3.1. Comparison of the incidence of oral mucosal irritation reactions before and after implementation

The incidence of oral mucosal irritation reactions in patients prior to implementation was 20.00%, which was significantly higher than that observed post-implementation ($p < 0.05$). See **Table 1**.

Table 1. Comparison of the incidence of oral mucosal irritation reactions before and after implementation (n, %)

Group	Example count	Redness and swelling	Pain	Burn	Overall incidence rate
Prior to implementation	45	5 (11.11)	3 (6.67)	1 (2.22)	9 (20.00)
Upon implementation	45	1 (2.22)	1 (2.22)	0 (0.00)	2 (4.44)
c^2	-	-	-	-	5.075
p	-	-	-	-	0.024

3.2. Comparison of adverse event incidence rates before and after implementation

The incidence rate of adverse events prior to implementation was 15.56%, while the incidence rate after implementation was 2.22%. The incidence rate prior to implementation was higher than that after implementation (*p*

< 0.05). See **Table 2**.

Table 2. Comparison of adverse event incidence related to operations before and after implementation (n, %)

Group	Example count	Hydrofluoric acid leak	Collateral casualty	Reagent misuse	Overall incidence rate
Prior to implementation	45	1 (2.22)	2 (4.44)	4 (8.89)	7 (15.56)
Upon implementation	45	0 (0.00)	0 (0.00)	1 (2.22)	1 (2.22)
c^2	-	-	-	-	4.939
p	-	-	-	-	0.026

3.3. Comparison of healthcare workers' occupational exposure rates before and after implementation

Following the implementation of standardized protective care procedures, no occupational exposures occurred among healthcare personnel, with a significantly lower incidence rate compared to the pre-implementation period (p < 0.05). See **Table 3**.

Table 3. Comparison of healthcare workers' occupational exposure incidence rates before and after implementation (n, %)

Group	Example count	Skin contact	Respiratory inhalation	Eye contact	Overall incidence rate
Prior to implementation	45	1 (7.69)	2 (15.38)	1 (7.69)	4 (30.77)
Upon implementation	45	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
c^2	-	-	-	-	4.727
p	-	-	-	-	0.030

3.4. Comparison of healthcare personnel compliance scores before and after implementation

Following implementation, healthcare professionals' scores for procedural compliance were significantly higher than pre-implementation levels (p < 0.05). See **Table 4**.

Table 4. Comparison of healthcare personnel compliance with operating procedures before and after implementation ($\overline{x} \pm s$)

Group	Example count	Preparation prior to operation	Protective measures during operation	Post-processing
Prior to implementation	13	77.94 ± 3.41	75.28 ± 3.50	78.12 ± 3.37
Upon implementation	13	92.45 ± 4.08	91.86 ± 3.94	93.09 ± 3.15
t	-	9.839	11.343	11.701
p	-	0.000	0.000	0.000

4. Discussion

Hydrofluoric acid is a highly corrosive chemical reagent that exerts potent irritation on human skin, respiratory tract, and mucous membranes. In clinical dentistry, it is frequently employed in inlay restorations to achieve secure bonding of porcelain inlays, thereby ensuring restorative efficacy [8]. To guarantee treatment safety, meticulous protective measures must be implemented during hydrofluoric acid procedures in dental practice, mitigating safety risks and hazards to safeguard both practitioner and patient wellbeing. Currently, routine protective measures are employed during hydrofluoric acid procedures in dental departments. However, inadequate protective awareness among some healthcare personnel, failure to properly wear protective equipment, or poor ventilation in operating rooms may increase operational hazards [9]. Consequently, standardizing protective care protocols and establishing a formalized protective care process is of paramount importance.

Following implementation, the probability of patients experiencing oral mucosal pain, burns, and other irritant reactions was significantly lower, with procedure-related adverse event rates also reduced compared to pre-implementation levels ($p < 0.05$). Analysis indicates that the standardized protective care protocol facilitates comprehensive patient assessment, enabling the development of personalized protective measures tailored to individual circumstances. Pre-procedure communication regarding the risks and precautions associated with hydrofluoric acid procedures enhances patient cooperation. During procedures, applying Vaseline around the patient's mouth and using saliva ejectors to aspirate vapors generated during handling reduced irritation to the oral mucosa from hydrofluoric acid vapors and waste liquid, thereby decreasing the incidence of irritation reactions [10–12]. The standardized protective care protocol also provided systematic training for healthcare personnel, enhancing their awareness and skills in protective measures while standardizing operational procedures, thus reducing procedure-related adverse events [13]. Concurrently, healthcare personnel demonstrated significantly higher scores for procedural compliance post-implementation compared to pre-implementation, $p < 0.05$. The incidence of occupational exposure among healthcare personnel was markedly lower following implementation, $p < 0.05$. This indicates that standardized protective nursing protocols effectively mitigate occupational exposure risks during hydrofluoric acid procedures, primarily through enhanced procedural standardization and compliance, thereby safeguarding occupational safety for healthcare personnel.

5. Conclusion

In summary, when performing hydrofluoric acid procedures in dental outpatient departments, standardized protective care protocols must be strictly adhered to. This ensures healthcare professionals operate within established guidelines, minimizes safety risks for both staff and patients, and guarantees both therapeutic efficacy and safety. Such protocols may be promoted for implementation across dental treatment settings.

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Disclosure statement

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