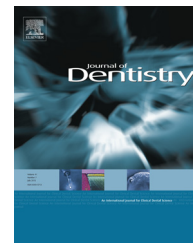


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Review

Anatomy of sodium hypochlorite accidents involving facial ecchymosis—A review



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ABSTRACT

Objectives: Root canal treatment forms an essential part of general dental practice. Sodium hypochlorite (NaOCl) is the most commonly used irrigant in endodontics due to its ability to dissolve organic soft tissues in the root canal system and its action as a potent antimicrobial agent. Although NaOCl accidents created by extrusion of the irrigant through root apices are relatively rare and are seldom life-threatening, they do create substantial morbidity when they occur.

Methods: To date, NaOCl accidents have only been published as isolated case reports. Although previous studies have attempted to summarise the symptoms involved in these case reports, there was no endeavour to analyse the distribution of soft tissue distribution in those reports. In this review, the anatomy of a classical NaOCl accident that involves facial swelling and ecchymosis is discussed.

Results: By summarising the facial manifestations presented in previous case reports, a novel hypothesis that involves intravenous infusion of extruded NaOCl into the facial vein via non-collapsible venous sinusoids within the cancellous bone is presented.

Conclusions: Understanding the mechanism involved in precipitating a classic NaOCl accident will enable the profession to make the best decision regarding the choice of irrigant delivery techniques in root canal débridement, and for manufacturers to design and improve their irrigation systems to achieve maximum safety and efficient cleanliness of the root canal system.

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1. Introduction

Sodium hypochlorite (NaOCl) is routinely used in root canal treatment as a chemical adjunct to mechanical débridement of the root canal system.^{1,2} It is an excellent irrigant in terms of its ability to function as a lubricant during biomechanical preparation of the root canals, and to dissolve pulpal tissues and the organic components of the smear layer.³ The free chlorine released by NaOCl in the form of hypochlorite ions also enables it to function as an excellent antimicrobial agent against microbiota and viruses by irreversibly oxidising their enzymes.⁴ With prolonged application, NaOCl is also anti-fungal against *Candida* species, although it may not readily dissolve their β -glucan cell wall.⁵ Sodium hypochlorite is also very effective for flushing and displacing loose debris inside the canal space, but the apical extent of its effectiveness is a function of the depth of insertion of the irrigation needles.^{6,7} Sodium hypochlorite is highly alkaline (pH 11-12.5) and is a strong oxidising agent of proteins.⁸ Complete haemolysis of red blood corpuscles occurred when they came into contact in vitro with NaOCl at dilutions as low as 1:1000 (prepared from 5.25% full-strength bleach). Placement of undiluted and 1:10 dilutions of NaOCl on the cornea of rabbits resulted in moderate to severe irritation that healed after 24-48 h. Intradermal injections of undiluted, 1:1, 1:2, and 1:4 dilutions of NaOCl produced painful skin ulcerations but no ecchymosis.⁹ These disturbing in vitro results had actually been observed in actual accidents that occurred to the eye and skin in patients undergoing root canal treatment.^{10,11} In addition, very low concentrations of NaOCl (>0.01%) were found to be lethal to human fibroblasts in in vitro cell cultures.¹² Injection of NaOCl into canine femurs ex vivo also resulted in compromising the integrity of cancellous bone and degradation of its collagen organic matrix.¹³ Likewise, the microstructure, organic content, and mechanical strength of bovine cancellous bone were dramatically altered at the bone surface after NaOCl treatment.¹⁴ Thus, if used injudiciously, NaOCl is very toxic and destructive to intraoral soft tissues, the periradicular vasculature and cancellous bone where it can elicit severe inflammatory responses and degradation of the organic components of these tissues.

Ideally, irrigants should be confined to the root canal system during root canal treatment. This is not always possible, however, as extrusion of irrigants, including NaOCl, beyond the apical foramen may occur during over-instrumentation, in teeth with open apices,¹⁵ and through sites of external resorption or perforation along the cavity walls.¹⁶⁻²¹ Binding of the irrigation needle tip inside a canal and use of too much irrigation pressure may also result in extrusion of irrigant into the periradicular tissues, leading to tissue destruction and necrosis.²² When used as a root canal irrigant, it is essential that NaOCl is prevented from entering the periradicular regions, injecting into the maxillary sinus or soft tissue spaces, which may result in severe and often life-threatening NaOCl accidents.

A survey conducted on 314 diplomates of the American Board of Endodontics indicated that only 132 members reported experiencing a NaOCl accident.²⁰ In that survey, significantly more female patients experienced NaOCl

accidents compared with males, with the rationale being the decrease in bone thickness and density in the former sex group. The condition occurred mostly in maxillary teeth versus mandibular teeth, and more often involved posterior teeth instead of anterior teeth, because of the closer proximity of the roots to the buccal bone surface. Patients' signs and symptoms generally resolved within a month. The authors concluded that NaOCl accidents are relatively rare and that they could be caused by additional factors such as anatomical variations or communication with fascial spaces through fenestrations of the root tips through the overlying bone, rather than by faulty irrigation alone.

2. Types of NaOCl accidents

Three types of NaOCl extrusion accidents have been reported in the literature: careless iatrogenic injection, extrusion into the maxillary sinus, and extrusion or infusion of NaOCl beyond the root apex into the periradicular regions.

2.1. Careless iatrogenic injection

Hermann et al. reported a case in which an anaesthetic carpule consisting of 1.8 mL of 5.25% NaOCl was inadvertently used for a mandibular block and injected into the pterygo-masseteric space and the inferior dental nerve.²³ The injection resulted in massive oedema involving the pterygomandibular space and the peritonsillar and pharyngeal areas, as well as immediate trismus. Likewise, Gursoy et al. reported a case in which NaOCl was inadvertently injected into the palatal mucosa in lieu of local anaesthetic solution, resulting in ulceration and necrosis of the palatal mucosa but without bony involvement.²⁴ There was no facial ecchymosis associated with both of these case reports.

2.2. Extrusion of NaOCl into the maxillary sinus

Inadvertent injection of NaOCl into the maxillary sinus has been described in three case reports with complications varying from inconsequential,²⁵ to complaint of burning sensation and accompanying nasal bleeding,²⁶ to severe facial pain requiring hospitalisation and operative intervention under general anaesthesia.²⁷ A possible reason for NaOCl extrusion into the maxillary sinus was provided by Hauman et al. in their review, stating that the alveolar bone becomes thinner with ageing, particularly in areas surrounding the tooth apices.²⁸ In such cases, the root tips projecting into the sinus are covered only by a thin bony lamella and the sinus membrane and there would be minimal resistance to flow of irrigants into the maxillary sinus. Recently, Khan et al. reported apically-directed pressures of 2.6 mm of Hg using an unbound side-vented needle with a flow rate of 1 mL/min positioned at 1 mm from working length.²⁹ In an earlier study, Jiang et al. used a higher flow rate of 6 mL/min with needles in the same position,³⁰ in which case the apically-direct pressure would have been 72 mmHg.²⁹ In either case, sufficient irrigation pressure would cause extrusion of NaOCl into the maxillary sinus if the Schneiderian membrane was missing. Sleiman³¹ reported complaints by a female patient referred for

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