A critical analysis of research articles related to the topic of Hypochlorite accidents in Endodontics

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The incidence, presentation and management of hypochlorite accidents in the endodontic patient

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Endodontic failure is due to microorganisms, which colonise the necrotic tissue in the root canal system (Mohammadi & Yazd, 2008), the microflora of which contains mainly obligate anaerobes (Zehnder, 2006).

In order to ensure endodontic success, organisms must be eliminated from the entire canal (Mohammadi & Yazd, 2008). Mechanical preparation is augmented with irrigants to cause disinfection of the entire canal space (Baser Can, Karapinar Kazandag, & Kaptan, 2015), and the ideal irrigant should dissolve necrotic tissue, inactivate endotoxin, prevent smear layer formation and be antimicrobial all at once (Zehnder, 2006).

Sodium hypochlorite, the most commonly used and widely available irrigant, fulfils these criteria (Chaudhry, Wildan, Popat, Anand, & Dhariwal, 2011). However, it is a solution that is not entirely without danger. Hypochlorite accidents, where the irrigant reaches periapical tissues or an allergic reaction occurs as a result of contact with the soft tissues, can result in pain, severe inflammation, necrosis and nerve damage as hypochlorite is caustic to vital tissues and has allergic potential (Chaudhry et al., 2011; Farook et al., 2014; Zehnder, 2006). Becker et al reported the first instance of hypochlorite accident in the literature in 1974 (Becker, Cohen, & Borer, 1974) and since then several studies have documented cases, including by Kleier et al in 2008 who found that around 42% of surveyed practitioners reported experience with hypochlorite accidents, with more women than being affected, higher risk of maxillary teeth over mandibular teeth and more posterior over anterior teeth involved (Kleier, Averbach, & Mehdipour, 2008). It is therefore imperative for clinicians to be able to understand, identify, manage and moreover to prevent this unwanted complication by adapting their procedures accordingly.

Hypochlorite in endodontic treatment

Hypochlorite has been used as an endodontic irrigant since 1920 and has always been cheap and easily available (Mohammadi & Yazd, 2008; Spencer, Ike, & Brennan, 2007). A strong base with a pH over 11, concentrations of 0.5-6% are used in root canal treatment, the upper value being about the equivalent of household bleach (Baser Can et al., 2015; Chaudhry et al., 2011; Mohammadi & Yazd, 2008).

Hypochlorite effectively dissolves necrotic tissue and results in dissolution of fat into fatty acid salts and glycerol, reducing solution surface tension in the process. It is proteolytic, and oxidises proteins to form nitrogen, acetaldehyde and formaldehyde, making it toxic to cells at concentations above 0.5% (Mohammadi & Yazd, 2008; Zhu et al., 2013). Although an effective antimicrobial irrigant by oxidizing bacterial enzymes and having a more profound effect on necrotic over vital tissue, hypochlorite is irritating on contact with vital tissue and can cause damage to endothelial cells and fibroblasts in addition to inhibiting neutrophil migration (Mohammadi & Yazd, 2008; Pelka & Petschelt, 2008). There is therefore debate over the optimal concentration of hypochlorite in endodontics with a fine line between toxicity and effectiveness (de Sermeno et al., 2009).

The Hypochlorite Accident

Periapical Extrusion

Complications as a result of periapical extrusion of hypochlorite result in chemical burns, neurological complications or airway obstruction. Instant severe pain and immediate swelling are observed, which can be accompanied by ecchymosis (de Sermeno et al., 2009; Pelka & Petschelt, 2008; Zhu et al., 2013). Inflammation and tissue destruction ensue, leading to ulceration and local or extensive necrosis. If the hypochlorite has been extruded into the sinus, in addition to acute sinusitis, irritation of the throat and nose bleeds, the patient may report the smell of chlorine (Chaudhry et al., 2011; Spencer et al., 2007). Bowden et al reported an incident of airway obstruction after extrusion which involved the floor of the mouth and associated tissues – a life-threatening complication (Bowden, Ethunandan, & Brennan, 2006).

Intra-orally, the tooth may present with sensitivity to palpation and percussion, apical swelling and swelling localized to the area around the tooth, with radiographic findings showing increased periodontal ligament space suggestive of air emphysema due to hypochlorite extrusion (de Sermeno et al., 2009).

Rarely, hypochlorite accidents result in nerve damage, presenting as paraesthesia, anaesthesia or dysaesthesia. First described by Witton et al in 2005 in a case of facial nerve damage, it is assumed that nerves are directly affected by contact with hypochlorite, which may result in difficulty swallowing, reduced lip competence and asymmetry on smiling and lip movement (Witton & Brennan, 2005). Pelka and Petschelt reported a case of paraesthesia resulting from a hypochlorite accident that lasted several years and affected mimic

muscles, rendering the patient disfigured and severely affecting her quality of life (Pelka & Petschelt, 2008).

Allergic reaction

First reported by Sulzberger in 1940, Hypochlorite can cause also cause anaphylaxis, which can present with urticaria, bronchospasm, shortness of breath and hypotension (Chaudhry et al., 2011; Spencer et al., 2007; Sulzberger, 1940). Even with concentrations as low as 1%, severe sequelae have been reported (Mohammadi & Yazd, 2008). Not necessarily achieving allergy status, many individuals can have a non-allergic hypersensitivity to hypochlorite which may manifest similarly (Hensten & Jacobsen, 2005). It is not simply apical extrusion that can cause allergy however – spillage of hypochlorite and any contact with the patient's mucosa can cause erythema and sublingual or submandibular swelling or oesophageal erythema, which may lead to airway obstruction requiring urgent hospital admission (Chaudhry et al., 2011).

Why does it happen?

Hypochlorite accidents are the result of an interplay of technical errors in treatment and patient factors.

In order to react with hypochlorite, irrigant must reach vital tissues surrounding the tooth or come in contact with skin or mucosa (Kleier et al., 2008). A theory proposed by Zhu et al suggests that patency filing may increase the risk of a hypochlorite accident by making the apical foramen patent (Zhu et al., 2013). Incorrect determination of working length and over-instrumentation, perforation through the lateral wall of the tooth, excess pressure on the plunger whilst irrigating or wedging the irrigating needle in the canal can also result in extrusion of hypochlorite (de Sermeno et al., 2009; Zhu et al., 2013).

Anatomical variation contributes greatly to the incidence of hypochlorite accidents. Teeth that protrude through the buccal bone in the apical part facilitate the contact between irrigant and soft tissue (Baser Can et al., 2015). This has been shown in a study by Behrens et al, in which CBCT imaging of an hypochlorite accident evidenced lower bone density buccally adjacent to the root, allowing access of the solution to the soft tissue (Behrents, Speer, & Noujeim, 2012). Similarly, root resorption causing perforation or chronic periapical infection leading to localized bone destruction or root fracture can result in tissue access for hypochlorite (Bosch-Aranda, Canalda-Sahli, Figueiredo, & Gay-Escoda, 2012; Gernhardt, Eppendorf, Kozlowski, & Brandt, 2004; Kleier et al., 2008; Pelka & Petschelt, 2008).

Secondary infections are thought to occur due to necrotic tissue, but also due to intra-canal microorganisms being forced out to the tissues through the apex of the tooth, thus posing a further risk of infection and complication after the event (Witton & Brennan, 2005).

Prevention

As some of the effects of hypochlorite accidents are so devastating, prevention is of utmost importance. Pre-operatively, the patient should be made aware of the risk of using hypochlorite as an irrigant as part of their pre-procedure informed consent, and to ensure that they are not allergic to the products involved in their root treatment (Chaudhry et al., 2011). Should they be sensitive or allergic, it is advisable to use a different irrigant or, if the patient is unsure, refer them for allergy testing (Behrents et al., 2012).

Diagnostic radiography should be completed to check for anatomical variations and immature apices (Mohammadi & Yazd, 2008). Should this be suspected, procedures should be adapted to minimize risk. CBCT can identify anatomical variations such as buccal plate fenestrations or dehiscence but the radiation dose and exposure would not be justified in every case (Behrents et al., 2012).

Procedure preparation should involve the selection of an appropriate concentration of hypochlorite. Higher concentrations of hypochlorite are associated with more accidents and worse outcome (Farook et al., 2014; Zhu et al., 2013). In line with the requirements under Control of Substances Hazardous to Health Regulations 2002, the exposure of chemicals or harmful substances to staff and patients should be limited, which includes preparing hypochlorite at a lower concentration (HSE, 2002). Prior to approaching the patient's tooth with hypochlorite, rubber dam should be placed to avoid contact of hypochlorite with the oral cavity, and well-fitting eye protection should be worn by all parties involved (Al-Sebaei, Halabi, & El-Hakim, 2015).

During treatment, it is important to ensure the access cavity has appropriate preparation and angulation, especially when accessing the root canal system through an extracoronal restoration (Chaudhry et al., 2011). Instrumentation to the correct working length is essential, and when using hypochlorite, a side vent needle on a luer-lok syringe, kept in motion with low plunger pressure to prevent binding of the tip is recommended (Mohammadi & Yazd, 2008; Spencer et al., 2007). A further risk reduction can be achieved by using negative pressure irrigating systems (Farook et al., 2014). A bleeding canal may be a sign of perforation and should be

investigated before proceeding (Chaudhry et al., 2011).

Management of the hypochlorite accident

Currently there are no absolute guidelines for the management of hypochlorite accidents, but a conservative approach to management is recommended (Spencer et al., 2007). The hypochlorite accident is akin to a medical emergency, and immediate action is required.

Once recognized as a hypochlorite accident, the procedure should be stopped and the patient informed, reassured and calmed to avoid panic. Irrigation with copious saline should be performed, after which the tooth should be left on open drainage (Farook et al., 2014; Mohammadi & Yazd, 2008). As the patient is likely to experience significant pain, long acting infiltration anaesthesia may be administered at this point and non-steroidal anti-inflammatories prescribed (Baser Can et al., 2015). Bosch-Aranda et al have advised the use of intramuscular Diclofenac; most dental practitioners in the UK would not have this accessible in practice nor would some be comfortable administering this as first line treatment, so oral NSAIDs are thought to be sufficient (Bosch-Aranda et al., 2012). To reduce the risk of secondary infection, Amoxicillin or Metronidazole for allergic patients can be prescribed (Spencer et al., 2007) and several studies have recommended the use of antihistamines (Baser Can et al., 2015; Behrents et al., 2012). Post-operative instructions for the patient should include the use of cold compresses for analgesia in the initial days, switched to warm compresses to encourage local circulation (Baser Can et al., 2015; Farook et al., 2014). It is essential to arrange a review visit within days in order to assess progress and place a temporary seal on the tooth and follow up with the patient until resolution has been achieved, taking the opportunity to refer to hospital if symptoms worsen. It may be wise to document the episode with clinical photographs (Chaudhry et al., 2011; Spencer et al., 2007). There is no reason the root treatment cannot be completed once the patient has recovered – obtaining a CBCT may indicate the reasons for the incident, and a change of irrigant may reassure practitioner and patient.

It is important to know when to refer the patient for treatment in a hospital setting. Farook et al proposed that this could be in part decided by assessing the level of swelling – noting that swelling of the affected side is more than 30% compared to the contralateral should be considered for referral (Farook et al., 2014). To prevent extensive long-term sequelae, it is important to correctly assess the need for referral.

In a hospital setting, the patient will usually receive intravenous steroids to reduce the inflammatory response, combined with intravenous antibiotics to reduce secondary infection (Chaudhry et al., 2011). If the airway is obstructed, high flow oxygen and intubation may be required (Bowden et al., 2006); in cases of Ludwig's angina where there is diffuse submandibular and sublingual swelling, incision and drainage may be performed (Farook et al., 2014). Necrotic tissue is debrided surgically under general anaesthesia, and may carry with it further complications such as wound contracture (Chaudhry et al., 2011).

In order to be able to effectively manage a hypochlorite accident, practice protocols for management and structured training should be completed, much like emergency training. This should include the steps after the event, but also the management of the patient including how to handle the conversation about the nature of the injury, which may be a difficult conversation to have.

Conclusions and Practice implications

Reports of hypochlorite accidents are fortunately rare compared with the millions of root canal treatments that are performed every year. It is imperative that the patient is aware not only of the risk of failure of endodontic treatment, but also of the substances in use during the procedure, and informed consent about possible negative effects of irrigant solution must be mentioned and documented to avoid possible lawsuits should a hypochloride accident present itself. In cases of patients with open apices, known anatomical variations that would increase the risk, or hypochlorite allergies, alternative irrigant solution should be used. Should an accident occur it should be handled in line with suggested methods above and, if severe, be referred. Hypochlorite is still the most widely used and most effective endodontic irrigant, but care should be exercised in its use – lower concentrations will still deliver effective results, at a reduced risk to the patient.

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