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Ferric Sulfate in Dentistry – A Review

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ABSTRACT:

Ferric sulfate (Fe2[SO4]3) is a widely used coagulant and local hemostatic agent in dentistry that was first used in medicine in 1950's. It is used in a variety of fields including dermatology and dentistry, and it is thought to have hemostatic properties due to chemical interactions with blood proteins. FS has gained widespread acceptance as a pulpotomy medicament in modern dentistry; however, it has several applications in other fields of dentistry that have received little attention. As a result, the goal of this review is to explore the various applications of FS in dentistry.

KEYWORDS: *Ferric sulfate, haemostatic agent, bleeding, haemostasis, dentistry.*

INTRODUCTION:

Controlling haemorrhage is essential in dental procedures for good field visualisation. Dentists perform a wide range of operative procedures, including pulpotomy, tooth extraction, biopsies, endosseous implant placement, periradicular and periodontal surgery, all of which may necessitate haemorrhage control [1,2]. The most common method for controlling bleeding is to apply mechanical pressure to the wound surface. When cotton balls or gauze pads are used, fibres may be left in the surgical site. These fibres may cause a foreign body reaction and cause healing to be delayed [3]. The use of hemostatic agents is another method for controlling bleeding [4]. In dentistry, various agents such as ferric sulphate and Ankaferd Blood Stopper (ABS) are used to control haemorrhage. Ferric sulphate, denoted as FS [Fe2(SO4)3], is a trivalent iron sulphate (Iron (3+) sulphate is a compound of iron and sulphate with a 3:2 iron (3+) to sulphate ion ratio). It has a rhombic crystalline salt, is dark brown or yellow in colour, and is soluble in water at room temperature. It is created by combining sulfuric acid, a hot solution of ferrous sulphate, and an oxidising agent. In the field of dermatology, it was first used as Monsel's solution in 1856 [5]. Blood protein agglutination is thought to be caused by the reaction of blood with ferric and sulphate ions. Thus, the capillary orifices have been obturate by bonded proteins [6].

CHEMICAL FORMS:

There are two chemical forms of ferric sulphate available:

Ferric subsulfate [$Fe_4(OH)_2(SO4)_5$] (Monsel's solution)

Monsel's solution (20% FS) is an effective styptic agent in skin and mucosal biopsies [5,7,8]. However, the ferric and ferrous salts are corrosive and harmful to both soft and hard tissues, causing subsequent tooth staining due to their high acidity (72%, pH<1) [7]. Postoperative soft tissue complications include delayed reepithelialization and dyspigmentation [9]. It also has a reactive and degenerative effect [5,10]. At 4 weeks, Armstrong et al. observed inflammation, a higher incidence of wound infection, and a delayed reepithelialization rate in punch biopsy wounds treated with Monsel's solution versus collagen matrix [11].

Ferric sulfate [$Fe_2(SO_4)_3$]

FS is a coagulative and haemostatic agent in a 15.5% solution that forms a ferric ion-protein complex when it comes into contact with blood. It mechanically seals the damaged vessels, resulting in haemostasis, and the agglutinated protein complex occludes the capillary orifices, preventing blood clot formation [5]. It causes a reversible local inflammatory response in the oral soft tissues [12]. Because of its quick action, the recommended application time is 1-3 minutes, and it should be placed directly against the damaged tissue. Above 15% FS solutions are highly acidic and may cause significant tissue irritation and postoperative root sensitivity.

MERITS OF FERRIC SULFATE:

- Adequate hemostasis
- Saving chair time
- Less time consuming
- Cost effective
- Effective and simple to use for control of bleeding, tissue management, and pulpotomies [7,9,11].

APPLICATION OF FERRIC SULFATE IN DENTISTRY:

As an Antimicrobial agent:

Ferric sulfate not only has hemostatic properties, but it also has antimicrobial properties. Under in vitro conditions, the antibacterial efficacy of ferric sulfate is comparable to 0.2% chlorhexidine digluconate but superior to Ankaferd blood stopper® against oral microorganisms such as Staphylococcus aureus, Enterococcus faecalis, Candida albicans, Porphyromonas gingivalis, Lactobacillus acidophilus, Lactobacillus salivarius, Streptococcus mutans [16]. This could be because of its acidic pH4 and cytotoxicity [3]. Furthermore, the occlusion of capillary orifices by agglutinated proteins prevents bacterial ingress [16].

In peadiatric dentistry:

In the last three decades, ferric sulfate has been widely used as a pulpotomy medicament to control pulpal bleeding in vital pulp therapy. It induces hemostasis by agglutinating blood proteins with ferric and sulfate ions and forming a sealing membrane at the damaged vessels of pulpal tissue [13]. The nonaldehyde form of ferric sulphate is preferred as a pulpotomy agent due to its haemorrhage-control mechanism, which is thought to be associated with physiological clot formation. When placed on the amputated pulp tissue for 5 minutes, this may reduce the chances of inflammation and internal resorption [17]. The most common type of ferric sulfate is minimal devitalization and pulp tissue preservation [13]. Because of physiological clot formation by the agglutinated proteins, ferric sulfate outperformed calcium hydroxide in terms of minimising inflammation and internal resorption [3,17].

Landau and Johnsen described using ferric sulfate as a pulpotomy medicament in monkey teeth [19]. With a 1-year follow-up, Fei et al. published the first human clinical trial using ferric sulfate with 100% clinical success compared to formocresol (77%) [13]. Ibricevic et al. described that ferric sulphate showed similar clinical and radiographic success rate as a pulpotomy agent for primary molar teeth after long term evaluation period, compared with formocresol. Ferric sulphate, because of its lower toxicity, may become a replacement for formocresol in primary molar teeth [41].

Fucks er al. demonstrated that ferric sulfate performed better when compared to formocresol in the pulpotomy of carious deciduous teeth, however without reporting statistically significant differences. Specifically, after 12 months, a total success rate of 92.7% and 83.8% was reported [42] and a clinical success rate of 96.7% and 86.7% was reported by Havale et al. in primary molars that underwent pulpotomy with ferric sulfate and formocresol, respectively [18]. Ozmen et al. compared three pulpotomy agents, such as formocresol, ferric sulfate and Ankaferd blood stopper (ABS), and reported a more favorable clinical success rate for FS (100%) than other evaluated materials (87% for both ABS and formocresol) after a follow-up of 24 months [43].

In restorative dentistry:

Ferric sulfate in concentrations ranging from 15.5% to 20% is one of the most commonly used chemical hemostatic reagents in restorative dentistry [20,21,22]. It is chemically impregnated into retraction cords in the chemomechanical gingival rebuttal technique, in which ferric sulfate is used at a concentration of 15%-25% for 3-10 minutes, and it provides greater sulcus displacement due to the combined physical and chemical effect [20,23].

Conrad and Holtan discovered that using ferric sulfate gingival retraction fluid in conjunction with translucent porcelain restorations resulted in black internal discoloration of the dentin beneath porcelain crowns [15]. Dentinal exposure to such highly acidic FS solutions (pH range of 0.7-2.0) for 30 seconds results in rapid removal of the superficial smear layer, and peritubular dentin was also lost after prolonged exposure [24]. Furthermore, removal of the smear layer by hemostatic agents has been shown to have a negative effect on the bonding mechanism of self-etching adhesive, which may promote marginal microleakage and discoloration [15,25,14]. As a result, cavity disinfection-associated resin composite restorations are material specific [26]. Cohesive failures were observed in primary dentin bonded with self-etch adhesive systems following the application of FS [27].

Ebrahimi et al. discovered that contaminating dentin surfaces with ViscoStat® for 60 seconds before applying adhesives reduced the shear bond strength of the adhesive to the dentin. The majority of the observed failures were adhesive [28]. To achieve better results during impression making or bonding agent application, the hemostatic agents used before or during etching should be thoroughly rinsed away to create a dentin smear layer. However, rinsing alone cannot remove surface contamination, and thus the residual FS interfered with adhesive diffusion in dentinal tubules [28,29]. Because of the weak acidity of the primer in self-etch adhesives, they were unable to dissolve the contamination by ViscoStat®; thus, deeper penetration into dentin is impossible [29]. The proposed mechanism was that hemostatic agents cause bonding procedure derangement due to dentinal tubule obturation and dentinal

surface demineralization at different values [14]. It is strongly advised that FS be used only with etch-and-rinse adhesive systems. [23] When compared to normal dentin, the use of self-etching adhesive significantly reduced the bond strength of dentin contaminated with the hemostatic agent. Kuphasuck et al. discovered that the hemostatic agent has no effect on the total-etching adhesive's dentin bond strength [14].

In prosthodontics:

Ferric sulfate was first used as a coagulative and haemostatic agent during crown and bridge impressions by Fischer (1987) [7]. It is used for tissue displacement and is kept on for at least 30 minutes. [7,30] Nonetheless, its use in implantology for gingival displacement is unclear due to its ability to disrupt the setting reaction of polyether and polyvinyl siloxane impression materials [15,31]. Because of its iron content, FS stains gingival tissue yellow-brown to black for several days after application. It has been demonstrated that it interferes with the surface details of impression materials and discolours dentin by precipitating ferric sulphide in an anaerobic environment [15]. Irrigating gingiva and aesthetic restorations with water for at least 10 seconds removes the staining and discoloration effect of ferric compounds. Furthermore, two studies found that the surfactant effect of chlorhexidine gluconate helps achieve haemostasis in less time [31,32]. After applying ferric sulfate, Shaw et al. observed reversible damage to the connective tissue adjacent to the sulcular gingiva [34]. Nonetheless, when used for 10 minutes in the gingival sulcus, they cause minimal tissue damage [20,21,22].

In periradicular and endodontic surgery:

Controlling bleeding during any surgical procedure is essential, and this can be accomplished through practical and effective systemic or topical approaches. When applied in the bony crypt under light pressure, epinephrine pellets, either alone or in combination with a ferric sulfate-soaked pellet, are effective topical hemostats [34]. Aluminum chloride, either alone or in combination with ferric sulfate (Stasis®), appeared to be the most effective hemostatic agent for periapical bleeding control [35,36]. Vickers et al. reported that in one-third of the cases where ferric sulfate was used, some oozing of blood occurred in the bony crypt, necessitating suction to keep the root-end preparation dry [37]. However, ferric sulfate was found to be less effective than aluminium chloride in controlling bleeding. Kim and Kratchman suggested using FS only on small bleeding points on the cortical bone surface [38]. When ferric sulfate was left in place for maximum exposure, an intense inflammatory response including foreign body reaction and delayed osseous healing was documented histologically after 18 and 46 days [3]. However, when the surgical site is adequately curetted and irrigated before closure, ferric sulfate does not cause persistent inflammation or delay osseous repair [39]. Adequate hemostasis can be achieved by applying 20% ferric sulfate (Viscostat®) for 5 seconds during endodontic surgeries such as root-end resection, root-end preparation, and root-end filling [37].

For post extraction haemorrhage:

Although FS is not widely used to control post-extraction haemorrhage, it may help with mucosal tears or uncontrolled post-extraction haemorrhage in gingival tissues [40].

DEMERITS OF FERRIC SULFATE:

- Tissue discoloration
- Acidic in taste
- Adhesive bond strength reduction
- Risk sulcus contamination
- Causes microleakage under restoration [13,14,15].

CONCLUSION:

When compared to other chemical hemostatic agents, the Ferric sulfate has been equally effective as a local hemostatic agent. Ferric sulfate is a common astringent solution (15.5%) with numerous applications in dentistry. It is widely used as a hemostatic agent in dentistry. Its use in restorative and endodontic dentistry, paediatric dentistry, prosthodontics, and oral surgery is not well documented. As a result, more research into the effective application of Ferric sulfate in various fields of dentistry is required.

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