Abstract

Objective
The aim of the current investigation was to review techniques and materials available to achieve bleeding control during periapical surgery. An adequate bleeding control is crucial, since it improves vision in the surgical site, minimizes surgical time, enhances the root-end resection and filling, and reduces surgical blood loss, postsurgical hemorrhage and postsurgical swelling.

Method
An update is made of the aspects to be considered during bleeding control in periapical surgery.

Results
The hemostatic agents that have been proposed in the literature have characteristics that make them very different from each other, such as the mechanism of action, commercial presentation, hemostatic efficacy and systemic effects.

Conclusion
The hemostatic agents that have obtained the best results are ferric sulfate, calcium sulfate, aluminum chloride and epinephrine. Nevertheless, there is no consensus in the literature on which is the ideal hemostatic agent.

Keywords
Endodontic surgery; hemostatic agents; hemostasis; periradicular surgery.
Hemostasis in periapical surgery

Introduction

The ability to achieve sustained tissue hemostasis in the surgical site is crucial to the performance of periapical surgery. Adequate bleeding control improves vision in the surgical site, minimizes surgical time, enhances the surgical procedures (root-end resection, preparation and filling), and reduces surgical blood loss, postsurgical hemorrhage and postsurgical swelling.1

There is no consensus in the literature about what is the ideal hemostatic agent. Kim and Rethnam2 established in 1997 that a good agent should achieve hemostasis within a short period, be easy to manipulate, be biocompatible, not impair or retard healing, and be relatively inexpensive and reliable.2 The aim of the current investigation was to review techniques and materials available to achieve bleeding control during periapical surgery.

Hemorrhage control

The hemostatic agents that have been proposed in the literature have characteristics that make them very different from each other, such as the mechanism of action, commercial presentation, hemostatic efficacy and systemic effects.

Bone wax

Bone wax is a nonresorbable material composed of beeswax (88%) and isopropyl palmitate (12%). It is applied to the bony walls with pressure and its mechanism of action is mechanical, tamponading the narrow spaces. Its translucency and deep encrustation into the bone make its removal difficult.3

Ferric sulfate and calcium sulfate

The mechanism of action of ferric sulfate is chemical, producing the coagulation of proteins, so it acts in a similar way to cauterization.4 Lemon et al. and Jeansonne et al. studied the effects of ferric sulfate in rabbit mandibles; they achieved good hemostasis for 5 min.4 5 Scarano et al. compared the hemostatic efficacy of 20% ferric sulfate, calcium sulfate and gauze tamponade, and concluded that calcium sulfate produced a good level of hemostasis.6

Epinephrine

The amine-type sympathomimetic vasoconstrictors have been used as topical agents for the control of hemorrhage in periapical surgery5 (Figs. 1–8). Epinephrine produces vasoconstriction by stimulation of α-adrenergic receptors. Besner suggested that its use in periapical surgery can produce a systemic cardiovascular response.7 Vickers et al. evaluated the hemostatic efficacy and cardiovascular effects of ferric sulfate and pellets impregnated with racemic epinephrine, and concluded that both agents produced surgical hemostasis and found no statistically significant differences in systemic cardiovascular parameters with either of the materials.6 In a similar study, Vy et al. concluded that collagen sponges saturated with epinephrine provided excellent bleeding control without changes in blood pressure or heart rate.9

Aluminum chloride

In 2001, von Arx et al. used a paste composed of aluminum chloride and kaolin as a hemostatic agent,10 which is usually used to produce gingival retraction.11 12 They applied different hemostatic agents in the calvaria of 6 rabbits: bone wax, ferric sulfate (Stasis), aluminum chloride (Expasyl) and a combination of Expasyl and Stasis.10 They concluded that Expasyl alone or in combination with Stasis was the most effective agent.10 Jensen et al. used the same study design to compare 5 hemostatic methods: Expasyl and Stasis; Expasyl, Stasis and freshening the bone defect with a bur; Spongostan; Spongostan and epinephrine; and electrocauterization.13 The most effective methods in the reduction of bleeding were Expasyl and Stasis combined (P < 0.05) and electrocauterization. Menéndez-Nieto et al. compared the hemostatic efficacy of epinephrine and aluminum chloride in 99 patients and concluded that aluminum chloride produced better results (P < 0.05;14 Figs. 9–14).

Other agents and techniques

Resorbable gelatin-based sponges,13 15 oxidized cellulose,15 electrocauterization,13 16 17 carbon dioxide laser,18 chitosan19 and plant-based hemostatic agents20, 21 have been used to control hemorrhage in periapical surgery; however, their scientific evidence is limited.

Regarding adverse effects, in the presence of bone wax, scarring of the bony crypt is poor,
fibers of connective tissue appear, and there is no bone or hematopoietic tissue. In addition to delaying healing, bone wax increases the predisposition to infection and produces chronic inflammation with foreign body reactions. A histologic study showed a marked inflammatory tissue response toward aluminum chloride and bone wax within the immediate site of application, but no adverse tissue reactions were seen in the vicinity of the bone defects. The authors recommended that, before wound closure, the bony crypt be curetted or freshened using rotary instruments to remove any foreign material. Jensen et al. found that aluminum chloride and electrocauterization triggered adverse tissue reactions (necrotic bone, inflammatory cells, lack of bone repair); however, this tissue damage was not observed when the superficial bone layer was removed with rotary instruments. Peñarrocha-Diago et al. observed that the patients for whom aluminum chloride was used as the hemostatic agent suffered greater postoperative swelling than the patients treated with a vasoconstrictor. When ferric sulfate was used, normal healing with a slight foreign body reaction after curetting the cavity thoroughly and irrigating with saline was found. When the material was not completely removed from the cavity, foreign body reactions that delayed healing occurred, and in 2 of 10 cases, the specimens showed abscess formation in the center of the osseous defect. No adverse tissue reaction was found when calcium sulfate, epinephrine, resorbable gelatin-based sponges or chitosan were used.

**Conclusion**

Hemorrhage control is a key aspect of periapical surgery: A hemostatic agent should be biocompatible, easy to manipulate and able to achieve hemostatic efficacy in a short period. The hemostatic agents that have obtained good results are ferric sulfate and aluminum chloride; however, the tissue damage produced when the superficial bone layer was not removed and its relation to the prognosis must be considered. Other agents that have demonstrated good hemostatic efficacy without foreign body reactions are calcium sulfate and epinephrine.

**Competing interests**

The authors declare that they have no competing interests.
Hemostasis in periapical surgery

Fig. 11
Hemostasis after application of the aluminum chloride. The superficial bone layer was removed with rotary instruments.

Fig. 12
Evaluation of the retrograde filling with an endoscope.

Fig. 13
Tension-free soft-tissue flap closure.

Fig. 14
Periapical radiograph 1 year after the periapical surgery.

References