Abstract
Alveolar osteitis (aka “dry socket”) is a frustrating complication following tooth extraction, especially in the posterior mandible, that is characterized by intense pain that is not relieved by analgesics. Dry socket may result from bacterial-mediated inflammation of the socket leading to the dislodgment or disintegration of the blood clot that forms within the socket immediately after extraction. Bacteria like Actinomyces viscosus, Streptococcus mutans and Treponema denticola have been strongly associated with the occurrence of dry socket. High plasmin-like fibrinolytic activity has been associated with Treponema denticola, which explains the clot breakdown. Dry socket can be prevented by maintaining good oral hygiene, pharmacological agents and restoring the alveolar blood supply. We describe a novel technique for its possible prevention involving administration of Doxycycline dispersed in a local anesthetic solution, incorporated into a Gelfoam® carrier. Placement of doxycycline-gelfoam material following tooth extraction followed by suturing was performed. A preliminary case study found this treatment resulted in the patient reporting no pain and followed up over 7 days found no obvious signs of inflammation with closure of the extraction site. Further studies are required to understand the mechanism of action of the doxycycline carrier and its effect on bacterial species present and inflammatory mediators, but this may represent a favorable therapeutic for prevention of dry socket.

Introduction
Alveolar osteitis, also known as “dry socket”, is a painful condition following the extraction of a tooth. The etiology of alveolar osteitis is attributed to loss of the post procedure blood clot. Purported explanations involve bacterial breakdown of the clot, and endogenous fibrinolysis. Oral contraceptive use, smoking, surgical extractions, and an undesirable interaction between tobacco products with oral tissues, thus triggering a foreign body reaction and the clot breakdown. Hence, avoiding or treating the involved bacteria associated with dry socket is of prime concern in the prevention of alveolar osteitis. Besides maintaining good oral hygiene, research has been looking at treating dry socket with the administration of drugs that may target specific bacteria. Additionally, since loss of the blood clot is a sequential pathology in this condition, restoration of the blood supply of the alveolar bone is also of equal importance.

Materials and Methods
A 44-year-old male patient presented to the Periodontology Clinic at the School of Dental Medicine at Buffalo, NY. It was determined that his diagnosis was “aggressive periodontitis” and the treatment plan involved the extraction of several teeth. The patient was also a heavy smoker for the last 30 years, and currently smokes 2 packs per day. After several counseling episodes of smoking cessation, the patient finally reduced the number of cigarettes to six a day (self-reported by the patient).

Written and oral informed consent was obtained from the patient for the extraction of tooth number 31. Vital signs were documented. A right inferior alveolar nerve block was administered using lidocaine 1:100,000 (2% epinephrine). Tooth number 31 was then extracted using a forceps technique. A Doxycycline/local anesthetic soaked Gelfoam® sponge was then placed into the apical portion of the socket. A 3-0 chronic gut suture was placed over the socket in a “Figure of 8” pattern. Post-operative instructions were then explained, and given in written form to the patient. Given the patient’s smoking history, we hypothesized that post operative “dry socket” was a likely occurrence.

Results
The patient was contacted on the evening of surgery, and the day after surgery, in order to determine his post-operative status. No pain or discomfort was reported. The patient mentioned that he was able to carry out his routine activities. The patient was also followed up, in person, a week after the procedure. He self-reported that during the time from extraction to the time of follow up, he smoked approximately 10 cigarettes a day. The extraction site did not display any evidence of erythema, or other inflammatory signs. There was almost a 70% approximation of the buccal and lingual flap over the socket.

Discussion
At the cellular level:
Dry socket is caused due to the fibrolysis of the blood clot post extraction of the tooth. There are several theories associated with the development of Alveolar Osteitis. However, the most common belief held is the initiation of the inflammation pathway via micro-organisms. Fibrinolysis is a physiologic process that dissolves the fibrin deposits by enzymatic digestion of the fibrin into fragments. Fibrin is a by-product of injury in the body and is increased during bleeding, especially post extraction. Extraction of a tooth results in the trauma of the alveolar bone, which results in the release of the direct extrinsic tissue activators such as tissue plasminogen activators and endothelial plasminogen activators and indirect tissue activators that contain bacterial by products like streptokinase and staphylolysin that bind to plasminogen to form an activator complex that then cleaves other plasminogen molecules to plasmin. Post release of these factors, plasminogen is transformed to plasmin resulting in the clot dissolution by the disintegration of fibrin. Bacteria like Actinomyces viscosus, Streptococcus mutans and Treponema denticola have been strongly associated with the occurrence of dry socket. High plasmin-like fibrinolytic activity has been associated with Treponema denticola, which explains the clot breakdown.

Hence, avoiding or treating the involved bacteria associated with dry socket is of prime concern in the prevention of alveolar osteitis. Besides maintaining good oral hygiene, research has been looking at treating dry socket with the administration of drugs that may target specific bacteria. Additionally, since loss of the blood clot is a sequential pathology in this condition, restoration of the blood supply of the alveolar bone is also of equal importance.

Conclusion
Doxycycline enables the suppression of the proinflammatory cytokines that may initiate the downregulation of the protein kinase C pathway. At low doses, it is known to inhibit collagenase, gelatinase and metalloproteinases. Subclinical doses are effective in avoiding inflammation or reduce its progression, especially because it is rapidly absorbed and has a prolonged half-life with potential preventive or antagonistic effect toward the damaging stimuli.

Many studies have employed the intra-alarveolar use of antibiotics, steroids, and hemostatic agents in the prevention of dry socket. More recently, no standard of care has been adopted by our profession for post extraction prevention of dry socket. Tobacco related infections have been shown to predispose to the development of alveolar osteitis. Bacteria that are commonly involved are Actinomyces viscosus, Streptococcus mutans and Haemophilus influenzae. These bacterial types are associated with delayed healing of extraction sites, high plasmin-like fibrinolytic activities, and indirect activators of fibrinolysis. Doxycycline has an inviable antimicrobial effect on the growth of these microorganisms.

As for the incorporation of the local anesthetic with the vasocostritor “epinephrine”, a question involving the use of the vasoconstritor leading to the malfornation of blood clot might arise. Studies have suggested a higher incidence of dry sockets with the administration of infiltration anesthesia before the temporary ischemia leads to poor blood supply. However, the ischemia is relative, lasting only one to two hours. It is then followed by reactive hyperemia, which makes it irrelevant in the disintegration of the blood clot. It is currently accepted that local ischemia due to a vasoconstritor in local anesthesis has no role in the development of alveolar osteitis. The use local anesthesis as a Diluent, as it provides several hours of post operative pain control. The epinephrine provides for local hemostasis.

The gelatin sponge (Gelfoam®), an effective and economical clot stabilization material, is purified porcine skin gelatin. It helps to accumulate the Doxycycline, which, without the sponge, would simply slough from the socket. The major benefit of using this material is that it is completely absorbable, and doesn’t need to be removed. It easily resorbs into the surrounding tissues. The material size is small enough for single patient use, and under direct compression of excessive material it is easy to manipulate and conform to post extraction sockets. Additionally, the Gelfoam® sponge is relatively nonreactive, which makes the procedure economical for routine use.

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