The Legacy of Cocaine in Western Dentistry

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Abstract

Cocaine has long been used by different cultures for its psychoactive properties (Meyer & Quenzer, 2019); but upon purification of the substance by German scientists, cocaine became widely used in medical and dental settings. Within dentistry, cocaine has been used both topically and as an intraoral injection (Calatayud & González, 2003; Meyer & Quenzer, 2019). However, unwanted side effects led to the development of cocaine analogues. This paper works to explore how cocaine became the first local anaesthetic in dentistry and how its powerful influence is still observed within the modern dental field.

Keywords: cocaine, western dentistry, side effects, local anaesthetic, cocaine analogues

Historically, cocaine in the form of coca chewing has been used by a variety of cultures for religious and ceremonial purposes (Meyer & Quenzer, 2019). Today, the white powdery substance is often associated with recreational drug use and is a frequent topic of discussion regarding the decriminalization of illicit drugs in British Columbia (CBC News, 2024; First Nations Health Authority, 2024). Although cocaine's history in mainstream products such as *Coca Cola* has been widely recognized by lay media (Lee, 2021; May 1988; National Post Staff, 2023), it's influential use within the medical field has not been as broadly appreciated. While local anesthetics are commonplace within modern dental offices, often making procedures more tolerable and reducing patients' anxieties, this was not always the case (Calatayud & González, 2003). It was not until the late 19th century when the first local anesthetic was used within dentistry — Cocaine (Calatayud & González, 2003). Unlike general anesthesia, local anesthesia acts within a restricted anatomical area (National Health Service (NHS), 2021); this specificity allows patients to remain conscious throughout the procedure and is best suited for minor operations (NHS, 2021). Although cocaine is no longer used as a local anesthetic in dentistry, its legacy lives on in analogue products such as lidocaine (Nathan et al., 2016). This paper analyzes the use of cocaine within dentistry and the substance's influence on modern anaesthetics.

Cocaine in Dentistry

Origins

Cocaine belongs to a group of drugs known as psychomotor stimulants and is an alkaloid that occurs naturally in the leaves of the *Erthroxylon coca* plant (Meyer & Quenzer, 2019). This plant is indigenous to regions of South America and its leaves were commonly chewed by Incan and Spanish populations (Brain & Coward, 1989; Meyer & Quenzer, 2019). Through the mechanical act of chewing, cocaine is extracted from the coca leaves and delivers its

psychoactive effects throughout the body (Meyer & Quenzer, 2019). Although coca leaves typically contain between 0.6% to 1.8% cocaine, the concentrated, purified form of cocaine allows the substance to be used for more than its stimulatory effects (Meyer & Quenzer, 2019). The substance was first purified and chemically characterized by German scientists in the late 1850's and through this process, cocaine's functional use in scientific and medical settings became quickly evident (Meyer & Quenzer, 2019). The purified and processed form of cocaine, also known as cocaine hydrochloride, is highly water-soluble, allowing the substance to easily enter the body through mucosal layers, such as the mouth and nose. This property of purified cocaine also works to increase the efficacy of administration routes such as injection (Meyer & Quenzer, 2019).

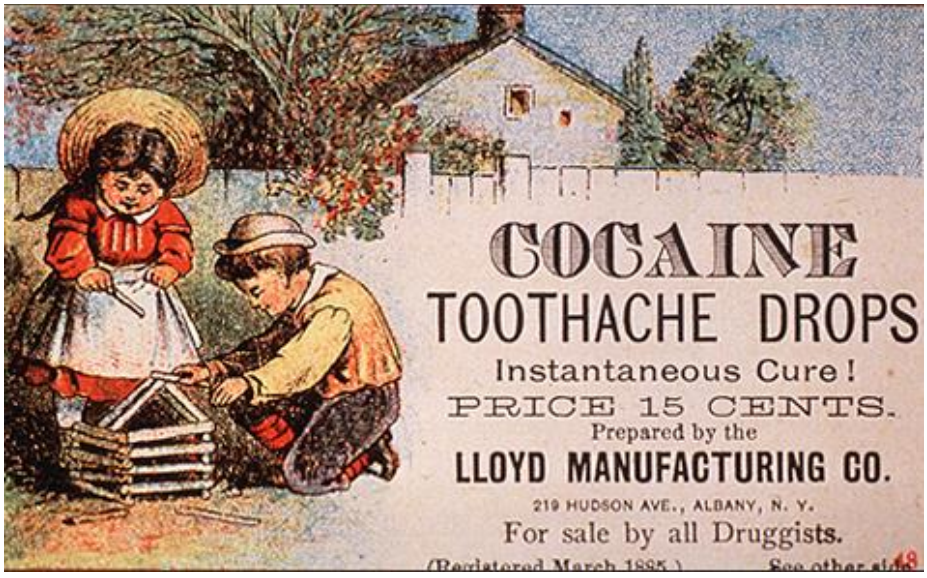
The topical pain-killing properties of cocaine were early recognized by individuals such as the Spanish Jesuit missionary, Berabé Cobo, and neurobiologist, Paola Mantegazza, who recommended the chewing of coca leaves for alleviation of tooth pain (Brain & Coward, 1989). Although cocaine was long-known to be a topical pain-killer, animal models played an important role in identifying the effects of intraorally injected cocaine (Calatayud & González, 2003). In 1865, Peruvian doctor, Thomas Moreno y Maïz, found that isolated areas on rats, guinea pigs, and frogs become unresponsive following cocaine solution injection (Calatayud & González, 2003). Despite this finding, the substance was not employed in dental procedures until nearly 20 years later (Calatayud & González, 2003).

In 1884, William Stewart Halsted and Richard John Hall expanded the use of cocaine within a dental context when the drug was injected into facial nerves to improve patients' pain and discomfort during dental surgery (Calatayud & González, 2003; López-Valverde et al., 2011). The surgeons noted that a 4% cocaine hydrochloride solution facilitated painless tooth

extractions when injected into patients' inferior alveolar nerve (innervating the cheek, lips, chin, bottom teeth, and gingivae) and anterior superior alveolar nerve (innervating the upper canine and incisor teeth, maxillary sinus and the inferior meatus) (Calatayud & González, 2003; López-Valverde et al., 2011; Nguyen & Duong, 2021). Although Latin American societies had been using cocaine topically to treat toothaches for centuries, the use of cocaine in other Western cultures prompted the creation of products such as Cocaine Toothache Drops (Figure 1) (National Library of Medicine, n.d.); these cocaine-containing tooth drops were even given to teething infants (Meyer & Quenzer, 2019).

Figure 1

Advertisement for Cocaine Toothache Drops



Note: 1885 advertisement for cocaine tooth drops by Lloyd Manufacturing Company. Reprinted from "Advertisement for medicinal drops to relieve toothache", by the National Library of Medicine, n.d. (https://collections.nlm.nih.gov/catalog/nlm:nlmuid-101400866-img). In the public domain.

Mechanism of Action

The experience of pain is felt through nerve activation which occurs when a neuron becomes depolarized (Meyer & Quenzer, 2019). Depolarization is achieved by an initial influx of sodium ions mediated by voltage-gated sodium ion channels (Meyer & Quenzer, 2019). While cocaine is commonly associated with feelings of euphoria by increasing the availability of serotonin, norepinephrine, and dopamine at neural synapses in the brain, in concentrated doses the substance also inhibits voltage-gated sodium ion channels and triggers vasoconstriction (Meyer & Quenzer, 2019). The combination of voltage-gated sodium ion channel inhibition and vasoconstriction makes concentrated cocaine an effective local anesthetic by providing long-lasting sensory impulse inhibition (Meyer & Quenzer, 2019).

Side Effects

Although cocaine became widely known as a local anaesthetic within the dental community, the substance was quickly abandoned due to its unfavourable properties and negative side effects (Calatayud & González, 2003). Patients would often experience increased heart rate and euphoria during dental procedures (Nathan et al., 2016). Dentists and physicians attempted to reduce cocaine's unwanted effects by diluting the anaesthetic solution, however, due to the addictive properties of cocaine, many individuals continued to develop cocaine use disorder (Calatayud & González, 2003; López-Valverde et al., 2011). Identification of cocaine's addictiveness encouraged the removal of cocaine from the dental field and prompted the reintroduction of general anesthetics such as nitrous oxide and ether (Calatayud & González, 2003). Although general anesthetics are less addictive than cocaine, local anaesthesia is generally safer and promotes greater patient satisfaction (NHS, 2021; NHS, 2022). Local anaesthetics allow for faster patient recovery and eliminate side effects such as nausea and vomiting (NHS,

2021; NHS, 2022). The benefits of local anesthesia in medical and dental settings were evident. Although cocaine was no longer suitable for patient use, the drug promoted the development of synthetic substances with the same nerve-blocking properties but with less addictive potential (Calatayud & González, 2003; Nathan et al., 2016).

Influence on Modern Local Anaesthetics

Although the injection technique employed by Halsted and Hall in 1884 continues to be used by dentists today, the injected anaesthetic is now a synthesized analogue of cocaine (Nguyen & Duong, 2021). German surgeon, Heinrich Braun, was the first to establish a criteria for an effective cocaine replacement (Wildsmith & Jansson, 2015). Braun stated that local anesthetics should have a better therapeutic ratio than cocaine, infiltrate tissues easily, readily absorb into the body without significant side effects, be chemically stable when heat sterilizes in water, and work well in conjunction with epinephrine (Wildsmith & Jansson, 2015). Although cocaine induces vasoconstriction on its own, this effect could not be achieved with a cocaine analogue, requiring the addition of epinephrine to increase the duration of the analogue's analgesic effects (Brain & Coward, 1989).

Procaine

The earliest analogue of cocaine is procaine which was developed in 1905 (Nathan et al., 2016). Procaine, also known as Novocaine, is similar to cocaine in its ability to inhibit voltage-gated sodium ion channels, but the drug does not produce the feelings of euphoria associated with cocaine use (Nathan et al., 2016). Interestingly, the brand name for procaine, Novocaine, was generated by combining the Latin word for new, "novus" and cocaine (Merriam-Webster, n.d.). Although procaine has proven to be less addictive than cocaine, it has also been proven to be a poor substitute (Ayuse et al., 2020). Many individuals develop an allergy when exposed to

procaine because of the substance's unique ester group (Ayuse et al., 2020). Additionally, procaine requires high concentrations of epinephrine to produce the same level of analgesic effect and lasting duration as cocaine (Calatayud & González, 2003; Nathan et al., 2016).

Lidocaine

Since procaine, many other cocaine analogues have been synthesized including bupivacaine and lidocaine (Nathan et al., 2016). In 1948, lidocaine, under the brand name Xylocaine, was developed by the Swedish pharmaceutical company, Astra, which eventually replaced the use of procaine in dental procedures (Nathan et al., 2016). As a cocaine analogue, lidocaine mimics cocaine's mechanism of action by inhibiting voltage-gated sodium ion channels which thereby prevent sensory nerve impulses; however, lidocaine does not impact dopamine, norepinephrine, or serotonin transporters (Adinoff et al., 2009). Unlike procaine, lidocaine contains an amide group instead of an ester group; therefore, individuals are less likely to generate allergic responses towards the drug (Nathan et al., 2016). Lidocaine also produces a deeper anaesthesia compared to procaine (Nathan et al., 2016). Additionally, even though lidocaine is not a vasoconstrictor, requiring co-administration with epinephrine, the substance quickly takes effect and has a modest duration time, averaging between 170 and 190 minutes (Nathan et al., 2016). As lidocaine does not share the same unwanted characteristics as procaine or the addictive properties of cocaine, the drug has remained prominent in the field of dentistry and is still commonly used in many dental procedures today including fillings, root canals, extractions, and dental implants (Nathan et al., 2016).

Current Uses

Within medicine, cocaine continues to be used as an intranasal anaesthetic (Smith & Rockley, 2002). In the United States, products such as Numbrino and Goprelto, which contain

4% cocaine hydrochloride, are approved for intranasal use in the context of nasal cavity procedures (Lutfallah et al., 2023). The evident difference between dental and nasal surgery is the anatomical structures involved. Nasal cavity surgery presents the unique challenge of nasal congestion (Lutfallah et al., 2023). Unlike safer analogues such as lidocaine, cocaine exhibits an intrinsic decongestant effect, making it better suited for nasal cavity procedures (Smith & Rockley, 2002). Despite cocaine's continued use in medicine, it is not without caution. The Federal Drug Association requires a boxed warning on approved cocaine hydrochloride products indicating the medication's risk of abuse and dependence (DailyMed, n.d.). While cocaine has not been approved in Canada for medical use, it is evident that the substance was the first successful local anaesthetic which helped to revolutionize many surgical procedures.

Conclusion

The introduction of cocaine as the first dental local anaesthetic worked to revolutionize the field of Western dentistry; its influence within the dental field is still observed today with the common use of cocaine analogues such as lidocaine (Calatayud & González, 2003; Nathan et al., 2016). While other countries such as the United States have begun to re-exploit cocaine's pain-killing properties within select surgical procedures (Lutfallah et al., 2023), the Canadian government has yet to comment on or approve cocaine for medical use. Given cocaine's addictive properties and the availability of other fast and long-acting analogues (Calatayud & González, 2003; López-Valverde et al., 2011; Nathan et al., 2016), it is unlikely that Canadians will see cocaine re-adopted into the medical field. Nonetheless, it is important to recognize how the drug has impacted professions such as dentistry, for without cocaine analogues, dental work would not be as fast, painless, or accessible as it is today.

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