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Review Article

Chilled Solutions: Cryotherapy's Impact on Periodontics

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Abstract

This comprehensive review delves into the multifaceted applications of cryotherapy in periodontics, focusing on its mechanisms, historical evolution, and clinical efficacy. Cryotherapy, utilizing intense cold to purposefully destroy tissue, emerges as a promising avenue in periodontal care, particularly in procedures such as gingival depigmentation and addressing specific conditions. The historical overview traces its roots from ancient cold therapies to modern cryosurgery techniques, showcasing its evolution and widespread adoption in medical and dental fields. The mechanisms of action highlight its effectiveness through reduced blood flow, metabolic activity, and neural inhibition, making it a virtually painless procedure. The review explores cryotherapy techniques, including open and closed systems, providing insights into controlled tissue freezing. In gingival depigmentation, cryotherapy proves valuable in achieving aesthetically pleasing results, with potential advantages over traditional techniques. A comparative analysis of cryotherapy methods in gingival hyperpigmentation treatment reveals varying outcomes, necessitating further research for a comprehensive understanding. The review also explores cryotherapy's applications beyond pigmentation, such as in managing localized juvenile spongiotic gingival hyperplasia and gum enlargement in Sturge-Weber syndrome patients. Despite drawbacks like unpredictable swelling, cryotherapy stands out as a valuable, patient-friendly tool in periodontics, offering non-invasive alternatives for various dental procedures. The abstract encapsulates the review's emphasis on cryotherapy's potential advancements, effectiveness, and versatility in periodontal treatment.

Keywords: *Cryotherapy; Periodontics; Gingival Depigmentation; Cryosurgery; Dental Support Structures; Mechanisms of Action; Comparative Analysis; Hyperpigmentation Treatment; Cryogenic Temperature Chamber; Cryogens; Joule-Thomson Principle; Gingival Plastic Surgery; Pediatric Periodontics; Sturge-Weber Syndrome; Tissue Freezing; Aesthetic Concerns; Non-Invasive Dentistry*

Introduction

Periodontics, a specialized field in dentistry, focuses on treating ailments affecting dental support structures. In the pursuit of innovative treatments, cryotherapy emerges as a promising therapeutic avenue in periodontal care. This review aims to explore cryotherapy's mechanisms, clinical applications, advantages, and limitations. By doing so, it provides a comprehensive overview, offering practitioners and researchers insights into the potential advancements in periodontal treatment.

Cryotherapy involves purposefully destroying tissue through the application of intense cold. After freezing, the necrotic tissue naturally sheds following cryosurgery [1]. This method is widely used in both medical and dental fields due to its effectiveness and simplicity [2]. Cryotherapy freezes tissue on purpose for therapeutic reasons, providing patients a preferred choice with minimal pain, no bleeding, and less scarring during healing. It's widely used in various dental procedures, especially for patients who can't undergo surgery due to age or medical history.

In cryosurgery, the term comes from the Greek word "kryos," meaning "frost". Despite the name, it's not just about cold but focuses on extracting heat. The therapy's effectiveness depends on factors like temperature change, exposure time, tissue conductivity, and the agents used, causing temperature shifts in tissues.

Cryosurgery aims to destroy cells and has a history in managing oral and lip cancer. Its applications have grown, reaching the head and neck area and being recommended after surgeries and injuries [3].

Historical overview

The Egyptians were the first to apply localized cold therapy for pain relief, and during the Franco-Prussian Wars, this freezing property was used to remove appendages. According to John Hunter in 1777, "the local tissue reaction to freezing involves local tissue necrosis, vascular stasis, and excellent healing." Hippocrates advised using cold to reduce edema, hemorrhage, and pain. In 1851, James Arnott described and demonstrated freezing therapy for malignant breast tumors using a solution of salt and ice. White, in 1899, was the first to employ extremely cold refrigerants for medical conditions, treating warts and other dermatological conditions with liquefied air. A.W. Pusey used the term "cryotherapy" in 1908 to describe the use of extremely low temperatures to cure skin lesions. Currently, cryotherapy involves cooling the body's surface without destroying tissue, whereas in cryosurgery, diseased tissues are frozen to death. Yamauchi and his team established the first cryogenic temperature chamber in the world in Japan in 1978 [3].

Cryogens

Low boiling point substances are referred to as cryogens. Liquid nitrogen (-196°C), nitrous oxide (-89°C), solidified CO_2 (-78°C) (dry ice CO_2 snow), chlorodifluoromethane (-41°C), dimethyl ether, and propane are among the regularly employed cryogens (-240°C, -420°C) [3].

Mechanism of action of cryotherapy

Applying cold or loud stimuli to target tissue triggers three physiological responses: reduced local blood flow, decreased metabolic activity, and inhibition of neural receptors [3]. Cryotherapy, a virtually painless procedure not requiring local anesthesia, directly diminishes nerve conduction capacity. Cold exposure stimulates thermal receptors, preventing nociception, and although freezing affects neuron's vitality, axon sheaths resist cold, enabling rapid regeneration and a return to normal function within one to two months [3].

Cryotherapy techniques: Open and closed systems for controlled tissue freezing

The available cryotherapy apparatus is classified into open and closed systems. Open systems involve direct application of cryogenic fluid (usually liquid nitrogen) to the lesion with a cotton swab or spray. In closed systems the tissue is frozen by a cryoprobe. Closed probe technique is useful as direct contact between cryogen and the tissue allows a more controlled and profound depth of freezing.

These probes follow the principles of Joule-Thompson expansion which enable substances to undergo a drop in temperature when moved from high pressure area to low pressure area. When nitrous oxide is released from high pressure inside the cryoprobe to the lower pressure cryotip, the drop in temperature allows freezing of the tissues to occur [4].

Cryotherapy in gingival depigmentation

Gingival pigmentation occurs due to melanin granules produced by melanoblasts, with the level of pigmentation determined by melanoblastic activity [5].

Gingival pigmentation appears either as a general deep-purple color or as irregular brown and light brown patches [6].

Though not a medical issue, the aesthetic worry of darkened gums due to excessive gingival pigmentation is a common complaint among individuals [7].

Dark pigmentation of the gums can have various causes, including genetics (regardless of age or gender, often called physiologic or racial pigmentations), tobacco use, and systemic disorders like endocrine disturbance, Albright's syndrome, malignant melanoma, Peutz-Jeghers syndrome, hemachromatosis, chronic pulmonary disease, Addison's syndrome, and von Recklinghausen's disease (neurofibromatosis). Additionally, factors such as antimalarial therapy, tricyclic antidepressants, and various local and systemic influences contribute to this discoloration. Gingival depigmentation is a periodontal plastic surgery procedure that aims to remove or reduce gingival hyperpigmentation using various techniques [8].

In an attempt to attain a gingiva that is free of pigmentation, various techniques have been in vogue for gingival depigmentation which include gingivectomy, mucosal excision by scalpel, abrasion techniques, free gingival grafts, chemical methods using escharotic agents, electrosurgery, cryosurgery, and more lately lasers [9].

The choice of a gingival depigmentation technique depends on factors such as clinical experience, patient affordability, and individual preferences, considering the distinct advantages and limitations of each procedure. Re-pigmentation is a common occurrence after gingival depigmentation, typically attributed to melanocyte activity, with varying timelines. Studies indicate re-pigmentation as early as 6 - 12 months for the scalpel technique, while cryosurgery and laser methods have shown a more extended duration, extending up to 24 months [10].

The Cryo Super Deluxe model no. 004B from BascoCryos Company in Chennai, Tamilnadu, India, utilizes the Joule–Thomson principle with nitrous oxide gas ranging from −70°C to −80°C at the probe tip for cryosurgical procedures. The targeted surgical area undergoes freezing until a visible icicle forms, and concentric circles are applied to freeze the entire area.

Subsequently, this process is repeated for an additional 10 seconds to ensure complete depigmentation of the gingiva.

Biopsy samples near the canine and first premolar were stained with Masson–Fontana for melanin activity. Cryosurgery showed lower melanocyte counts, indicating less recurrence compared to scalpel technique, although not statistically significant. This aligns with reports of delayed recurrence in cryosurgery, possibly due to prolonged melanocyte reactivation [11]. The migration of melanocytes and increased melanin formation in dark-complexioned individuals might contribute to these outcomes [12].

Individuals with darker complexions have a higher rate of melanin formation compared to those with fair complexions [13].

Gingival pigmentation is more pronounced in anterior teeth, possibly due to sunlight exposure [14].

Comparative analysis of cryotherapy methods in gingival hyperpigmentation treatment

Various treatments, including cryosurgery, aim to address concerns about hyperpigmentation by freezing and destroying pigmented tissue. Cryosurgery employs substances like liquid CO_2 or liquid nitrogen for rapid freezing, while diode laser therapy is another common approach [15].

In Darbandi., *et al*.'s study, a nitrogen oxide cryoprobe was used for gingival hyperpigmentation treatment. The results indicated that 60% of patients healed within 7 days, and all pigmented lesions were healed after a month. No recurrence was observed in follow-ups for up to 6 months, demonstrating 100% effectiveness within one month.

In contrast, the present study observed that gingival sites did not reach zero pigmentation after a single N2 cryotherapy session [16]. Additionally, repeated cryotherapy sessions did not alter the GPI index, suggesting a variation in effectiveness compared to Darbandi., *et al*.'s study [16].

Shirazi., *et al*.'s teenage study involved using a cotton swab dipped in liquid nitrogen for two sessions with two-week intervals in treating gingival hyperpigmentation. Results showed a gradual reduction in pigmentation severity and color intensity after three months. However, pigmentation recurrence was observed in the one-year follow-up, differing from the present study [17].

In conclusion, discrepancies in outcomes among studies suggest potential variations in the effectiveness of cryotherapy methods.

The study observed no recurrence of pigmentation in any treated gingival sites, whether treated with laser or cryotherapy, throughout the 12-month follow-up period [18].

Further research is needed to comprehensively understand cryosurgery outcomes in gingival hyperpigmentation treatment.

Other applications of cryotherapy in periodontics

Localized juvenile spongiotic gingival hyperplasia (LJSGH), a subtype of inflammatory gingival hyperplasia predominantly affecting children, often exhibits resistance to traditional periodontal treatment. Surgical excision, though associated with a recurrence rate of 6 - 16%, may be contraindicated in multifocal cases due to aesthetic concerns, necessitating exploration of alternative therapies. Cryotherapy, involving rapid freezing and thawing, emerged as a promising method with advantages like treating multiple lesions simultaneously and improved tolerance.

Leading to effective management through cryotherapy, which proved well-received by pediatric patients [18].

A case report describes a patient with Sturge-Weber syndrome facing gum issues. After scaling and root planing showed recurrence, cryotherapy using a closed nitrous oxide probe was successful. Cryotherapy was chosen for its hemostatic control, reducing surgical time, and fast tissue healing. Post-treatment, no pain or secondary infection was reported. Cryotherapy proves effective, suggesting it as a non-invasive, efficient in-office procedure for treating gum enlargement in Sturge-Weber syndrome patients without resorting to surgery [4].

Advantages

Cold therapy offers notable advantages, including minimal pain and discomfort, absence of bleeding, negligible scarring, easy application, preservation of inorganic bone structures, a low incidence of infection, no long-term side effects, and highly localized action. Its significant benefit lies in its applicability to patients for whom surgery is not recommended [3].

Disadvantages

Despite its merits, cryotherapy presents drawbacks such as unpredictable swelling intensity, imprecise freezing depth and area, and a reliance on operator expertise. A notable limitation is its inadvisability, particularly when the diagnosis of a lesion is uncertain [3].

Conclusion

In summary, this review underscores cryotherapy's promising role in periodontics, showcasing its effectiveness in diverse applications like gingival depigmentation and managing specific conditions. From historical roots to modern techniques, cryotherapy's mechanisms, controlled freezing methods, and advantages, including minimal pain and aesthetic benefits, are highlighted. The comparative analysis reveals varied outcomes in gingival hyperpigmentation treatment, warranting further research. Despite drawbacks like unpredictable swelling, cryotherapy emerges as a valuable, patient-friendly tool in periodontics, offering non-invasive alternatives for various dental procedures.

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Conflict of Interest

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