

Integrating Cryotherapy into Dental Practice: A New Frontier in Patient Care

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ABSTRACT

In the realm of dentistry, cryotherapy stands as a powerful cold therapeutic technique, revolutionizing various sectors such as postoperative care, edema reduction, and pain management. Its applications now extend beyond these areas to encompass oral cancer treatment, implantology, endodontics, and oral lesion management. As a cost-effective and minimally invasive solution, cryotherapy accelerates patient recovery by inducing vasoconstriction and modulating inflammatory responses. However, despite its advantages, challenges such as precise temperature control and other contradictory issues persist. To refine its procedures, enhance its effectiveness, and unlock its full potential in dentistry, more in-depth research is essential.

INTRODUCTION

Cryotherapy means “cold” therapy, coming from the Greek word “cryos.”. This technique is widely used in medicine as well as in dentistry, as it aims to create vasoconstriction and reduce pain, edema, and inflammation by changing tissue physiology due to extreme cold temperatures.¹ Salt and ice mixed together along with the application of this frosting temperature destroys the growth of cancer cells, which was first invented by James Arnott in 1851.² At the time of the Franco-Prussian War, for the very first time, it was the Egyptians who applied localized cold therapy to reduce pain in 1899 for the treatment of warts and some other dermatological conditions; extremely cold refrigerants were used with liquefied air. In 1908 for curing skin lesions, Pusey used the term ‘cryotherapy’. The first cryogenic temperature chamber was established in Japan by Yamauchi and his team in 1978.³

The scientific principle that cryotherapy follows is called Joule-Thompson expansion. It means the movement of substances from a high to a low-pressure zone area, which results in a temperature drop. Nitrous oxide is rapidly released from the high-pressure cryoprobe to the low-pressure cryotip, which causes an adiabatic expansion and thus leads to a frosty temperature, resulting in tissue freezing. Cryotherapy is a combination of rapid freeze-thaw cycles. It initiates vasoconstriction. If the tissue temperature is below 15 degrees Celsius, it happens to create a phenomenon called the ‘hunting phenomenon’. It’s a biphasic vasoconstriction-vasodilation cycle. This cycle prevents tissue perforation, though it is exposed to extremely cold temperatures.⁴

Initially, Cryotherapy was limited to the treatment of oral and lip cancer. But recently, several application procedures for the head and neck region can also be seen.² According to most of the studies, the main purpose of cryotherapy is pain control, which occurs most often after any endodontic procedures and surgical procedures. In the year 2015, cryotherapy was first introduced in the endodontic field by using a cold irrigating solution in the canal to reduce postoperative pain.⁵ The

temperature of that saline solution was 2.5 degrees Celsius, which was maintained for 5 minutes.⁴ There is a neuropeptide substance called substance P, which is associated with the perception of pain. Pain level experienced by the patient can be modulated by cryotherapy as it controls the release of substance P.⁴

In dentistry, now it's been used after intra-oral excisional surgery, tooth extraction, periodontal surgery, and implant placement procedures. Management of arthritis associated with temporomandibular joint disorder also adds to the list.²

Though local anesthetic agents are used widely as regional anesthesia, for mandibular molar teeth, local anesthesia cannot achieve the desirable pulpal anesthesia with inferior alveolar nerve block, especially in cases of symptomatic irreversible pulpitis. As cryotherapy introduces a multi-prolong approach to modulate pain, this procedure is beneficial. This procedure works by influencing nociceptor functions by reducing chemical mediator release thus decreases the activating threshold and manages the transmission of pain, and this is how cryotherapy reaches the climax of local anesthesia.⁴

In the case of precancerous and cancerous oral lesions, the most common method of eradication is surgical excision. Apart from surgical excision, cryotherapy can also be added to the list along with photodynamic therapy and laser therapy. It has multiple advantages as it freezes in situ and destroys local precancerous tissues. Cryotherapy also creates a relatively bloodless field, reduces the chances of secondary infection, and prevents scar formation afterward. Though it does not need expensive equipment, it's hard to maintain a constant low temperature during the procedure.⁶ Though cryotherapy is widely spreading in all fields of dentistry and in the overall medical field, there is a lack of evidence and experimental studies on its effectiveness, along with different drawbacks to overcome. So, it requires further studies and exploration in this procedure.

CRYOTHERAPY IN POSTOPERATIVE MANAGEMENT

Cold therapy is commonly employed in modern dental and oral surgical practices to mitigate pain, trismus, and edema following dentoalveolar procedures. The application of cold after surgery helps to impede local blood flow and counteracts

the rebound effect caused by vasoconstrictor-containing anesthetics. Consequently, lowering the temperature at the surgical site with cold applications has become the recommended standard in postoperative maintenance therapy.⁷

The effectiveness of cryotherapy in postoperative dentoalveolar procedures has always been a controversial topic. There are certain studies where the efficacy of cryotherapy in reducing pain and swelling post-third molar extractions has been observed. This method has demonstrated significant benefits in managing postoperative discomfort and inflammation but is not effective in the reduction of trismus.⁸ On the other side, one blind, randomized clinical trial was conducted on patients with symmetrical impacted mandibular third molars who underwent two separate surgeries, and the effect of cryotherapy was tested. Cold therapy demonstrated no beneficial effects on postoperative outcomes following impacted mandibular third molar surgery.⁹

During electronic research, it has been observed that a safe and efficient way to administer cold

therapy to control the postoperative course is the Hilotherapy system. Applying the Hilotherm system promotes quicker recovery of mandibular function by reducing the severity and duration of pain and edema. This method makes patients more comfortable and simplifies patient management for medical personnel.¹⁰

According to a study, post-operative pain following a single root canal procedure was successfully reduced by combining intracanal cryotherapy—which involves applying extremely cold saline into the root canal—with negative pressure irrigation.^{11,12}

One study assessed the analgesic effectiveness of intracanal cryotherapy in single-visit root canal procedures for irreversible pulpitis by delivering cold saline as a final irrigant using a 27-gauge side-vented needle. The findings showed that in individuals with apical periodontitis, which is characterized by inflammation at the root tip, this method significantly decreased postoperative pain. However, those without apical periodontitis did not see a discernible decrease in pain.¹³

To control swelling, discomfort, and inflammation surrounding the surgical site, cryotherapy may be helpful during the postoperative period of dental implant

surgery. Cryotherapy may help to promote early tissue healing and improve patient comfort throughout the recovery phase by reducing enzyme activity and tissue metabolism.¹⁴

Applications of cryotherapy may be beneficial for TMJ dysfunction, which is characterized by symptoms like joint discomfort, muscle soreness, and restricted jaw movement. For patients with TMJ issues, cold therapy can help reduce muscular spasms, ease pain, and improve jaw mobility.¹⁵

A non-pharmacological method of treating acute dental pain, such as toothaches brought on by pulpal inflammation or dental damage, can be managed with cryotherapy.^{16,17}

APPLICATION OF CRYOTHERAPY IN ENDODONTICS

Endodontics plays a crucial role in dentistry as it focuses on diagnosing, preventing, and treating diseases of the dental pulp and surrounding tissues.¹⁸ Endodontic treatment, primarily root canal therapy, helps save teeth that would otherwise require extraction due to deep decay, trauma, or infection. Poor oral health has been linked to systemic conditions like cardiovascular diseases and diabetes. Proper endodontic treatment prevents chronic infections that could contribute to such conditions. Endodontics prevents tooth loss and thus wards off misalignment, bite problems, difficulty in chewing, and bone resorption. Therefore; it helps maintain the integrity of the dental arch. Endodontics has significantly advanced over the past two decades, greatly enhancing the quality of care.¹⁸

Root canal treatment is a fundamental aspect of routine dental care. The main purpose is to promote peri-radicular tissue healing by thoroughly eliminating microorganisms through chemo-mechanical disinfection, followed by a tightly sealed obturation. However, post-endodontic pain and discomfort continue to be the primary concern of all dentists. Various chemical and mechanical factors related to endodontic treatment can contribute to postoperative pain and discomfort.¹⁹

Cryotherapy, the therapeutic application of cold temperatures, has emerged as a promising adjunct in endodontic treatment. By lowering pulpal and periapical temperatures, cryotherapy influences neurovascular responses, decreases inflammatory mediators, and enhances patient comfort.

The procedure of how to apply cryotherapy in root canal:

Cryotherapy in endodontics is administered using a specialized dental instrument designed with a conduit that connects to a fluid source. This instrument features a cryogenic cooling needle that receives the refrigerant from the delivery system. The needle, made of a flexible material, has an outer diameter of approximately 0.25 mm—small enough to fit within the root canal. This allows the cryogenic fluid to be effectively introduced into the canal, facilitating the cooling process.²⁰

The following are the applications of cryotherapy in endodontics:

1. Effect on postoperative pain: The early work in cryotherapy was initiated by Vera et al., who employed a 2.5°C cold saline rinse along with an Endovac irrigation system for 5 minutes. From this experiment, they observed a notable decrease in the temperature of the external root surfaces of teeth, with a drop of up to 10°C that persisted for approximately 4 minutes.²¹ Al-Nahlawi et al. recommended using cold saline to alleviate postoperative pain following endodontic procedures, in combination with negative pressure irrigation (EndoVac), which helps minimize debris extrusion and, consequently, reduce pain. However, a randomized clinical trial by Bazaid & Kenawi found that cold saline only reduced postoperative pain in cases of irreversible pulpitis with symptomatic apical periodontitis, but did not have an effect when normal apical tissues were present.¹⁹ A recent systematic review by Monteiro et al. demonstrated that the use of intracanal cryotherapy effectively reduced postoperative endodontic pain at both six and 24 hours.²⁰
2. Effect on dental anesthesia: Most of the time, the inferior alveolar nerve block is not achieved. Preoperative intraoral cryotherapy applied after an inferior alveolar nerve block did not achieve profound pulpal anesthesia in almost half of the mandibular molars with symptomatic irreversible pulpitis. However, intraoral cryotherapy could still be considered a practical and cost-effective adjunct to enhance the success rate of inferior alveolar nerve block in patients with symptomatic irreversible pulpitis. Cryotherapy generates a local anesthetic effect by decreasing the threshold for nociceptor activation and reducing the speed at which pain signals are transmitted.²²
3. Effect on fracture resistance of endodontically treated teeth: Assessment by Keskin et al, indicated that using intracanal cryotherapy as the final irrigant led to a decrease in the vertical fracture resistance of prepared roots compared to the control group.²⁰
4. Effect on *Enterococcus faecalis*: *Enterococcus faecalis* is an important organism in endodontic failure because it is highly resilient and can survive in the harsh environment of the root canal, particularly in cases of incomplete disinfection or inadequate sealing. This bacterium can persist in nutrient-poor conditions, such as when the pulp tissue is necrotic. Its ability to form biofilms makes it difficult to remove with conventional root canal disinfection methods, contributing to reinfection and treatment failure. Additionally, *Enterococcus faecalis* is often resistant to many commonly used antimicrobial agents, further complicating its elimination during endodontic therapy. Mandras et al. tested the combination of cryotherapy and 5 percent sodium hypochlorite to evaluate its potential microbicidal effects against *Enterococcus faecalis*.²³ This had an exceptionally positive effect on the reduction of the organism.
5. Effect on rotary NiTi instruments: Nickel-titanium (NiTi) alloys are known for their exceptional properties, such as shape memory, superelasticity, biocompatibility, and corrosion resistance, which enhance biomechanical preparation. Compared to stainless steel, NiTi offers better flexibility, adaptability, and torsional fatigue resistance. However, its pseudo-elastic properties can cause surface imperfections and reduced cutting efficiency (CE). To improve CE and wear resistance, various surface treatments, including cryogenic treatment, have been tested. Cryogenic treatment involves cooling the metal to extremely low temperatures using liquid nitrogen, which enhances microhardness, cutting efficiency, and fracture resistance. Research shows that deep cryogenic treatment improves the cutting efficiency of NiTi instruments and increases microhardness, although the impact on wear resistance and cyclic fatigue is less significant. Some studies suggest that cryogenic treatment leads to an increase in fracture resistance by promoting a phase change in the alloy, reducing internal stress, and improving overall performance.¹⁶

6. Cryotherapy in Apical Surgery: The application of cold saline or ice packs to surgical sites following periapical surgery has demonstrated reduced postoperative swelling and discomfort. Localized cooling of tissues may enhance wound healing and reduce postsurgical complications.¹⁶

Cryotherapy in endodontics offers a promising approach to reducing post-operative pain and inflammation. Further research and clinical trials will help optimize protocols and enhance their integration into routine endodontic practice.

TREATMENT OF ORAL LESIONS

Cryotherapy is a therapeutic technique that uses extreme cold to treat various oral lesions, including keratotic, hyperplastic, granulomatous, vascular, pigmented lesions, and salivary gland lesions, as well as gingival conditions.²⁴ The process involves freezing the targeted tissue, which leads to cell destruction and subsequent healing. The stages of cryotherapy, as described by Hocutt et al. (1982)²⁵, are as follows:

Stage 1: Sensation of Cold (1-3 minutes) The patient feels a cold sensation at the site of application. This is the initial response to the cryotherapy application.

Stage 2: Aching or Burning (2-7 minutes). The cold sensation progresses to a feeling of aching or burning. This stage indicates the onset of tissue freezing and cellular damage.

Stage 3: Local Numbness (5-12 minutes). The area becomes numb as the tissue freezes further. This stage is critical for achieving the desired therapeutic effect, as it ensures sufficient tissue destruction.

Stage 4: Deep Dilation (>12 minutes). Prolonged freezing leads to deep tissue dilation and further cellular damage. For effective treatment, especially after an injury, it is recommended to maintain cryotherapy for more than 12 minutes to ensure the tissue reaches Stage 3 (local numbness).

Cryosurgery, also known as cryotherapy, is indeed a valuable and minimally invasive treatment option for various skin and oral mucosa disorders in children. Its advantages make it particularly suitable for pediatric patients, especially those who may be fearful or anxious about medical procedures.²⁶ Below is a summary of the key benefits of cryosurgery in pediatric dentistry and dermatology: Non-invasive nature, no need for local anesthesia, minimal complications, ability to treat multiple lesions simultaneously, better tolerability in fearful children, ease of operation, reduced pain and discomfort and favorable cosmetic outcomes make this technique well tolerated by young patients.²⁷

Three typical oral precancerous lesions are oral leukoplakia (OL), oral erythroleukoplakia (OEL), and oral verrucous hyperplasia (OVH). About 90% of OL lesions exhibit hyperkeratosis and/or epithelial hyperplasia, 5% have carcinoma in situ or epithelial dysplasia, and 5% have invasive carcinoma, according to histology. Malignant transformation rates of OL lesions have been reported to range from 4–15% for granular or verruciform leukoplakia and 1–7% for homogenous thick leukoplakia.²⁸ Cryotherapy is an effective alternative treatment modality for oral precancers, even though surgical excision, laser surgery, and photodynamic therapy (PDT), can all alleviate oral precancerous lesions. Cryotherapy uses freezing in place to destroy lesional tissues locally. Bloodless treatment, a very low rate of secondary infections, and a relative lack of pain and scarring are some of its benefits²⁷. Both closed and open systems can be used for cryotherapy. Although closed-system cryotherapy offers more control over temperature, it necessitates advanced, costly, and delicate equipment. The cryoprobe is applied directly to the lesional surface to accomplish this.

Closed-system cryotherapy is typically appropriate for treating uniform, smooth-surfaced oral

lesions that are less than 1 cm in diameter due to the small and flat contact area of the cryoprobe end. In open-system cryotherapy, the cryogen is applied directly to the lesion using a portable spray device or a cotton swab. It is more challenging to keep the lesional tissues at a consistently lower temperature for the duration of the treatment. However, it does not require expensive equipment. The spray apparatus can treat medium-sized and large oral lesions with smooth or rough surfaces with open-system cryotherapy.^{29,30} Clinical outcomes of cryotherapy for soft tissues of the mouth typically include blister formation, necrosis, sloughing, healing process, subepithelial bleeding, and tissue edema. The size, location, and type of cryotherapy system used affect the degree of tissue death and the rate of tissue regeneration following cryotherapy. After cryotherapy, erythema, edema, or hyperemia usually develops immediately or within a few hours. After one to two days of worsening local swelling, superficial necrosis and ulceration occur, with a layer of white or yellowish necrotic pseudomembrane. A clean, granulating surface partially covered by the epithelium is left behind after the white or yellowish slough separates from the underlying tissue within the first week.³¹

PHYSIOLOGICAL EFFECTS OF CRYOTHERAPY ON ORAL TISSUES

The application of either heat or cold causes four fundamental physiological reactions: (i) A shift in temperature. (ii) Modifications to local blood flow. (iii) Inhibition or stimulation of cutaneous neuroreceptors by nerves. (iv) The metabolic activity of cellular tissue.⁷

Cryotherapy causes vasoconstriction and inhibits cellular metabolism by limiting biochemical processes, according to Vant Hoff's rule. In turn, this reduces the amount of tissue damage by lowering the need for oxygen and the generation of free radicals.³²

There is a common "hunting response" that is characterized by a cycle of vasoconstriction and vasodilation. Tissue experiences early vasoconstriction after being exposed to lower temperature ranges for more than 15 minutes. This is followed by vasodilation, which is mediated by the release of a chemical named 'H' that resembles histamine.³³ Adrenergic elements in the blood vessel network initiate this cycle, which persists as a sophisticated brain reflex.³⁴

Vasoconstriction lowers vascular permeability, thereby reducing the volume of fluid leaving the periapical tissue as transudate or exudate. This lowers swelling and tissue edema, which is frequently linked to periapical tissue following biomechanical preparation. Applying cold after surgery slows local blood flow and prevents the rebound effect that occurs after the use of local anesthetics, such as vasoconstrictors. Consequently, it has been proposed that using cold to reduce the surgical site's temperature is an effective postoperative supportive therapy.⁸

As a neurological effect, the nociceptive nerve fibers' nerve conduction speed is closely linked to the lack of pain. Cooling slows nerve transmission, inducing analgesia.³⁵

Cryotherapy blocks nociception inside the spinal cord by activating thermoreceptors, which contain temperature-sensitive nerve endings. Dental pain conduction is primarily attributed to myelinated A- δ fibers and non-myelinated C-fibers. According to Franz and Iggo, non-myelinated C-fibers deactivate at around 3°C, while myelinated A- δ fibers completely deactivate at 7°C.³⁶

Since faster sensory input by the larger myelinated A fibers temporarily closes the gate and prevents the unmyelinated C fibers from transmitting more painful impulses, it is assumed that gate control theory is believed to support this analgesic outcome of cryotherapy.³⁷ Furthermore, applying cold causes neuropraxia, which lowers tissue nociceptors' activation threshold and produces a brief local anesthetic effect. Therefore, a combination of a slower transmission of painful neural signals and a reduced release of chemical mediators of pain results in the analgesic action of cooling.³²

Cryotherapy's effect on cell metabolism increases the injured tissue's oxygen absorption, ultimately leading to tissue hypoxia and necrosis. Additionally, cryotherapy reduces cellular metabolism and tissue blood flow by 50%. As a result, it slows down metabolic reactions, limits free radical formation in tissues, and reduces oxygen consumption, preventing tissue hypoxia and additional tissue damage.³⁸

The temperature difference between the tissue and the coolant, the size and form of the cold pack, the duration of chilling, the tissue's thickness, the anatomical location of planned cryotherapy, and the therapeutic method all affect how much the tissue temperature varies during cryotherapy.²⁵

CONTRAINDICATIONS OF CRYOTHERAPY IN DENTISTRY

1. Cold-induced urticaria or Cold Hypersensitivity

This rare condition occurs when cold exposure triggers an allergic-like reaction, such as hives (urticaria), redness (erythema), and swelling. This adverse reaction results from vasoconstriction and a drop in tissue temperature when cryotherapy (cold therapy) is applied to a patient with cold hypersensitivity.¹

2. Raynaud's Disease

It is a condition that affects blood flow to the extremities, typically the fingers, toes, ears, and nose, and is most commonly triggered by cold or stress. It causes the blood vessels in these areas to constrict (narrow), reducing blood flow and leading to color changes, numbness, and cold sensations. If used in these patients, cryotherapy can cause further vasoconstriction, potentially exacerbating the symptoms of this disease.

3. Areas with increased risk of Tissue Necrosis

Cryotherapy should be avoided in areas with compromised blood circulation, a history of tissue necrosis, or open wounds and lesions, as its use could worsen the condition and delay healing.¹⁶

4. Infection

Applying cold to an area of active infection can potentially suppress the immune response and complicate the healing process further. These areas are absolute contraindications for the use of cryotherapy.⁷

5. Risk of Nerve Damage

Cryotherapy should not be used near sensitive nerves, such as those in the oral cavity, as it can cause permanent damage in these areas if the cold is applied for too long or at too low a temperature. Nerves in the oral cavity are very sensitive to temperature changes, and prolonged exposure to extreme cold can lead to temporary or permanent nerve damage, causing numbness, tingling, or pain.

6. Frostbite

In patients with pre-existing conditions affecting thermoregulation, improper cryotherapy use – such as prolonged excessive duration – can cause severe frostbite or increase the risk of hypothermia.

7. Other Diseases

Other diseases that are either absolute or relative contraindications for cryotherapy include blood dyscrasias of unknown origin, sclerosing basal cell carcinoma, squamous cell carcinoma, collagen vascular diseases, and pyoderma gangrenosum.

PRECAUTIONS FOR THE USE OF CRYOTHERAPY IN DENTISTRY

1. Duration of Application

The duration of cold therapy application should be monitored carefully. Excessive cold exposure can severely damage tissues and lead to frostbite or nerve damage. Therapeutically cold applications should only be limited to 10-15 minutes at one time. Different authors have suggested varying time intervals for cold applications. For example, LaVelle & Synder (1985) recommended limiting therapy time to 10-minute intervals instead of 20 minutes, arguing that it could achieve the same skin temperature with less of a "hunting" response. Meanwhile, Knight (1995) suggested a cooling and rewarming protocol with a 1:2 ratio, where ice was applied for 30-45 minutes at 1-2 hour intervals during the first 12-24 hours following injury. Another researcher proposed applying cold therapy post-surgery until the trauma response stabilizes, which typically within between 24 to 72 hours.²⁵

2. Tissue sensitivity

A patient's sensitivity to cold therapy should be carefully assessed, and cryotherapy parameters adjusted accordingly. Some patients may have hypersensitivity to cold due to underlying conditions such as dentinal hypersensitivity. Care should be taken in such cases.

3. Tissue damage

Prolonged cryotherapy can have a risk of tissue damage in areas of delicate mucosa, especially in the oral cavity where gingival tissues are also involved. Careful monitoring and controlling the duration and intensity of cryotherapy are essential to prevent tissue damage.³⁹

4. Protection of Sensitive Areas

Sensitive areas should be protected by placing a barrier (such as a cloth or gauze) between the cryotherapy source and the skin to prevent direct contact, with the skin thus reducing the risk of tissue damage.

5. Patient Comfort and Communication

Care should be taken to ensure the patient's comfort and understanding of the procedure. Any discomfort or pain during treatment should be addressed immediately, and cryotherapy should be adjusted accordingly.

6. Proper Temperature Regulation

Patient comfort should be ensured by using proper cryotherapy equipment with adjustable settings to maintain a suitable cold temperature for the specific treatment.

7. Post-Treatment Care: After cryotherapy, the patient should be observed for any signs of frostbite or numbness. Patients should be advised to avoid exposing the treated areas to excessive heat immediately after the procedure.

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