

Cryonics as Cryotherapy in Oral and Dental Care: A Clinical Review of Mechanisms, Devices, Care and Risk-Benefit Appraisal

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Abstract

Cryonics in expanded dentistry and oral medicine embraces various uses of Cytotherapeutic care. Oral Cryotherapy exists in different forms. (1) Cryosurgical ablation (purposeful tissue obliteration); (2) Non-ablative cooling, mainly (take out word to) as prophylaxis of mucositis from chemotherapy; (3) Vital Pulp-testing by pain induction for rapid vitality-pulp-testing by pain induction for rapid vitality-pulp-testing. This review assembles clinical indications, the simple biophysics of procuring “cold-freezing-on-demand,” indicates peri-operative care, describes some ubiquitous devices and cryogens, the results of cryotherapy, lays-out pragmatic advantages/limitations and disadvantages, and stresses diagnostic safeguards for pre-malignant lesions.



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Freezing;
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Abbreviations

ACS	Ablative Cryosurgery;
HSCT	Hematopoietic stem cell transplantation;
MNSCC	Multi National Support of Cancer Care’;
ISOO	International Society of Oral Oncology;
LOHT	Localized Oral Hypothermic Cryotherapy;
OPMDs	Oral Potentially malignant disorders;
OHCW	Oral Health Care Workers;
DPT	Dental Pulp Testing

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Introduction

Provenance and Clinical Outline

Cryology is the theoretical physical study of cold and freezing temperatures on matter in all its different states. Cryonics is the pragmatic discipline of the application of principles of cold temperatures to practical uses. Cryonics, is used not only in the study of cold temperatures in Medicine but also Oro-dental care. Cryotherapy is the pragmatic use of Cryosurgery, Cryotherapy is the pragmatic use of Cryosurgery, also called cryoablation, or Ablation Cryosurgery (ACS) which destroys vital tissues by freezing. In Medicine it is extensively used in dermatology, and more recently for breast tumors, in which liquid gas is transformed into ice to freeze and destroy living tissue.^{1,2,3} Cryosurgery in oral health care embraces two major applications and a third minor modality.⁴

Cryosurgery, also called cryoablation or Ablation Cryosurgery (ACS)

Which is intended to destroy vital tissues by freeze-thaw application cycles. Ubiquitous oral applications include chosen red and white benign oral mucosal locations and selected pre-malignant lesions. Astute experienced clinical skills for confident diagnosis and management are essential for successful use of ablation cryotherapy. Clinical therapeutic procedures vary with various cryogens, exposure times, freeze-thaw cycles, margins, and applicators.^{4,5}

Localized Regional Oral Hypothermia (LOHT)

An oral cryo-therapeutic support intended to protect oral mucosae experiencing chemotherapy by transiently mucosal perfusion and/or surface drug exposure as a collutorium, for consequent reduction of oral mucositis risk with specific regimens, on suspected areas.^{4,5,7}

Cold And Vital Tooth Dental Pulp-Testing (DPT)

Cryogenic kits are pragmatic diagnostic tools in endodontics used to assess the health and vitality of a tooth's nerves, and constituent cells in the pulp, by checking its response to cold stimuli. These tests are not always reliable but are commonly used to diagnose conditions like reversible/irreversible pulpitis or necrotic (dead) pulps. Cryogen liquids (like ethyl chloride or tetrafluoro-ethane) are used to create ice on demand for pulp testing. A vital pulp will invoke a painful response. Non-vital (a necrosed pulp) will not react.⁸

AIM

This review assembles clinical indications, explains the simple biophysics of procuring "cold-freezing-on-demand," indicates peri-operative care, describes some ubiquitous devices and cryogens, the results of cryotherapy, lays-out pragmatic advantages/limitations and disadvantages, stresses diagnostic safeguards for pre-malignant lesions, and indicates other possible uses.

Methods (Sequential Progress)

A search was done with Research-Gate and PubMed for information using Key words: Ablation; cryotherapy; cryosurgery; freezing; liquid nitrogen. Subjective selection combined with personal clinical practice experience provide insights included.

This below is a sequential progress based on Multi National Support of Cancer Care (MNSCC) and International Society of Oral Oncology (ISOO) guidelines for treating mucositis which includes: Cryotherapy suggestions with fundamental local destructive pathogenic mechanisms induced by cryobiology, appraisal of clinical protocols for indications of use, techniques applied and outcomes derived from studies on biopsy timing and follow-up on dysplastic oral lesions.^{9,10,11}

Discussion

Cryotherapy in Oral Medicine

Use of Ablative Cryosurgery (ACS) is frequently indicated for typical observed benign mucosal soft tissue lesions; these will include small visible or palpable minor lumps like mucoceles, fibromas, papillomatous lesions, lichen planus, some vascular-appearing lesions for which will have a reduced blood flow field and demanding minimal suturing needed for removal. Localised or reticulated, sessile red and/or white lesions, may be deemed Oral Potentially Malignant Disorders (OPMDs): Clinically if these lesions can not easily be rubbed off, they should be regarded with high suspicion for OPMDs. Ulcers that do not respond to topical anti-microbial treatments may be malignant.^{4,5,6,10}

ACS is used for lesions such as leukoplakia and/or erythroplakia, but diagnostic governance is critical: ACS is essentially a destructive necrotic technique and will negate or spoil reliable histopathologic assessment. Accordingly, should ACS be performed

appropriate pre-operative planning, for selected biopsy location is essential. Current (2026) practice guidelines stresses biopsy timing, biopsy selection, and long-term monitoring and follow-up for dysplasia. Dental practice limitations become important constraints with direct visual examination. ACS is more direct, easy and well controlled straightforward for clearly-circumscribed benign lesions with low diagnostic ambiguity. But for lesions with known dysplasia/malignancy tendencies the clinician's choice for a diagnostic pathway to select viable tissue for histopathology is essential both for surveillance and diagnostic support confirmation.^{10,11}

The Principle Foundation of Freezing

Most cryo-therapeutic devices produce cold-freezing-on-demand. These work on biophysical principles. In general, when matter changes from one state to another, (solid, to liquid to gas) there is an exchange of energy, either released or absorbed. With gases, by exploiting the Joule-Thomson Expansion Principle that states when a compressed gas (classically liquid Nitrogen, N₂O or CO₂) expands through a small orifice of a probe tip, it produces rapid cooling. Specially engineered devices with multiple interchangeable contact tips, like the Cryoprobe, are cooled to below zero 30-50° degrees Celsius, and can be applied to locations for freezing. Clinical application develops a localized frozen zone at the probe-tissue interface. The depth and shape depend on the probe design, contact area, contact time, and tissue perfusion. Usually, a frozen transepithelial seam of necrosis develops.

For Supportive Oral Cryotherapy, oral mucositis prevention and care in patients receiving autologous hematopoietic stem cell transplantation (HSCT). Patients are treated with a bolus of conditioning chemotherapeutic agents such as bleomycin, etoposide, 5-fluorouracil, methotrexate and combined with this treatment, it can disrupt the growth and maturation of oral mucosal epithelial cells leading to mucositis with basal cell loss and the onset of ulceration. The current guidelines for HSCT recommend oral cryotherapy (LOHT) to prevent oral mucositis. in patients receiving bolus 5-FU and high-dose melphalan.^{10, 11,12}

Conservative cooling methods would use ice chips, but there are reliable, symptom moderating intraoral

cooling devices as alternatives to ice chips, targeting designated area with standardized, tolerable cooling delivery.^{11,12} Oral cryosurgery reviews describe both open and closed systems used in dentistry by Oral Health Care workers. (OHCW).^{12,13}

Freezing of tissue is obtained by conduction: energy flows as heat flux from warmer tissue into adjacent cold sources; also, extra latent heat for water-ice phase transition is absorbed. Tissue perfusion is a "heat sink" that limits the freezing depth. Consequently, identical exposure times can yield different ice-ball sizes across different sites/lesions. These principles are stressed in reviews focusing on clinical practical variability noted in oral cryosurgery reports. With cryoablation cellular and vascular damage is realized mainly by freezing intra-cellular cytoplasm, and extra-cellular fluid with sterile ice crystal formations, and consequent cell injury with tissue-necrosis.¹⁴ Fundamental cryo-therapeutics identifies multiple, interactive biological pathways causing tissue injury from the freeze-thaw cycle. Freezing is reliably procured at -50°C [minus fifty degrees Celsius], and a rapid freeze and slow thaw is recommended.¹⁴

With ACS direct cellular injury is caused by extracellular ice formation; this increases solute concentration, causing osmotic dehydration. Low temperatures with rapid cooling forms intracellular ice with membrane and organelle disruption. Vascular injury happens from endothelial damage; micro-thrombosis forms, and local ischemia contributes to delayed necrosis and consequent lesion destruction. Repeated freeze-thaw dynamics augments overall injury as the lowest minimum achieved temperature becomes the dominant determinant of cell death.¹⁵

Supportive non-ablative localised hypothermic oral cryotherapy (LOHT) is achieved through regional hypothermia; this produces a vasoconstriction and a subsequent reduction of mucosal drug exposure during the short-half-life muco-toxic chemotherapy (e.g., bolus 5-FU). This mechanistic rationale is expounded in clinical guidance to moderate development of mucositis.^{14, 15}

Discussion

Perioperative Clinical Protocols

Mucositis prevention for supportive oral cryo-therapy embraces pre-, during- and post-operative care. Oral

assessment and education on timing and tolerability is done according to protocols and regimen-specific indications from MASCC/ISOO guidance.

Pre-Op Preparation

A comprehensive Medical History, should raise any red-flags to avoid invasive therapy. For example, immunocompromised, diabetic, or patients on anticoagulants, may need special support or modified treatment plans to optimize and maximize benefits. Contra-indications for doing cryo-surgery should be identified from these histories.

It is essential to ensure pre-operative preparation and treatment planning for Ablative Cryosurgery (ACS). An affirming diagnostic plan is a high-priority. Should the diagnosis be uncertain or any dysplasia is plausible, a plan for tissue biopsy for reliable histopathologic assessment is essential. Incisional biopsy before cryotherapy is indicated. Clinical judgement calls of risks from complications and healing derived from the lesion size/location, function, aesthetics, bleeding risk/anticoagulation, immune status, and patient ability to attend follow-up, must be assessed. These are all factors to be considered with insights from oral cryosurgery literature due to variable healing and recurrence patterns. Oral and Maxillofacial Surgery (OMFS) guidance indicates biopsy timing/type and follow-up for dysplasia.⁷

Risk-Benefit discourse and patient informed consent To minimize patient surprises, complaints and to optimize patient co-operation it is important to inform, explain and discuss the procedures, protocols, and expected reactions with the patient. In the practice of Medicine, there are no 100-percent guarantees of success, and the risk/benefits involved should be clearly laid out for the patient before undertaking any therapy. The following topics should be included in securing informed consent from the patient :- Anticipated oedema/swelling, blistering/slough, pain, healing time, recurrence possibility, and (site-dependent) scarring and functional risks. While all these are commonly included for patient consent to undergo oral cryosurgery, prior to any therapy an open direct discourse of how the patient is expected to honor their financial obligations, should be included. A written probable treatment plan with expected costs, and future attendances and appointments involved will minimize patient's post-op negative reactions.,^{9,10}

Although verbal instructions are regularly told to patients, these oral directives should be supported with written instructions, and given to the patient before the first appointment and post-op instructions after the procedure. Most patients receive cryo-ablutionary care as ambulant, outpatients, for selected lesions, and are not hospitalized during care. To minimize planktonic oral microbes during treatment, patients should rinse their mouth with 0.02% Chlorhexidine-gluconate mouthwash, immediately before any treatment.

During therapy, with localised regional hypothermia (LOHT), the use of a slurry of ice chips or a device-based cooling during the key exposure window is used. (e.g., guideline-referenced durations for bolus 5-FU). In special cases of oncology, cryotherapy should follow the specific protocol/guideline for the regimen, not a generic "always cool" rule. Some protocols advise against ice-chip cryotherapy with oxaliplatin due to concern for exacerbating acute cold-triggered symptoms e.g., pharyngo-laryngeal dysesthesias, even though many clinical studies investigated oral cryotherapy during oxaliplatin infusion and report uncertainty and context-dependence.

Post-Operative Care

Expected reactions should be laid out in simple terms: explanatory guidance about edema and tissue sloughing that may occur before re-epithelialization. For Oral Hygiene and wound care, these topics should be discussed: Biofilm dental plaque control by gentle brushing, avoidance of mechanical irritants from mastication of brittle foods, and frequent use of saline as a collutorium. If the patient notices any clear signs of infection, clear ongoing bleeding, or functional compromise, they should represent as an emergency. Specific verbal directives should be reinforced by giving the patient these written instructions after the procedure.

An anecdotal clinical directive is to use a mix of petroleum jelly, with a capsule of powdered tetracycline, and some local analgesic benzocaine paste, and topically applied to oral wounds one day after ACS; this gives some relief for most patients.

Patients should represent a week to ten days after treatment for monitoring and re-assessment. Follow-up appointments should emphasize

ongoing surveillance to assess resolution and recurrence for dysplasia-risk lesions, and determine if subsequent appointments with specialty guidance is needed. Post-therapy is sustained with continuing comprehensive oral care cited. Biofilm dental plaque control by gentle brushing, avoidance of mechanical irritants from mastication of brittle foods, and frequent use of saline as a soothing collutorium. Cryotherapy is preventive and supplements broader mucositis management guidelines.

Applications : Sources : Management

Cryotherapy properly executed does not promote bleeding; it is “bloodless” treatment. Secondary spreading infection is rare, and the treated areas heal with minimal scarring. The application of the cold induces tolerable pain, and use of concomitant local analgesia is unusual. Techniques vary for according to the lesions being treated.

Most treatments are successful with untoward unexpected healing complications. Single or multiple benign lesions can be treated, but recurrence and healing times vary with different lesion- types and/ or protocol used.

ACS can be done with an open or closed system. Most common is liquid nitrogen in a small cannister which gas is delivered in situ, via a direct focused spray, or by a specially designed applicator. With HSCT, LOHT is supported post-operatively with a slurry of ice-chips, or ice-cold water mouth rinses. The ice- and cold-water techniques may induce transient dental pain on existing vital teeth. For this reason, some specialized devices are used to avoid inducing dental pain.

Advantages and Disadvantages

The major advantages of ACS and LOHT are that it is minimally invasive and usually does not cause any haemorrhage or bleeding. Consequently, there is no need for use of sutures. Also, cryotherapy can be done without any anaesthetic on ambulant patients. The outcomes are acceptable esthetics, and affected areas heal, often being replaced by healthy tissue from the surrounding loci or area. The cost for cryosurgery and post-op support is usually minimal.

The disadvantages and limits of Cryotherapy are few, but definite. All dental clinics and institutions have different equipment and trained staff, and the heterogeneity of the presenting features confounds the protocols. With ACS freeze times, application cycles, cryogen liquids, defining treatable margins all may complicate standardization. Optimal techniques stubbornly deny standardization for comparative efficacy. Depth control of ice-balls with ACS is an enduring challenge, especially for open Liquid-N₂ approaches. With ACS healing can be miserable for the patient with resultant pain, swelling, blistering, and sloughing, and deeper/large freezes may risk scarring or functional issues depending on site. ACS involves a diagnostic risk, as ACS is destructive of tissues, and treatment can compromise histologic diagnosis if biopsy is not appropriately planned. Biopsies are essential accurately diagnosing mild, moderate or severe dysplasia, critical to diagnose for further advanced management and care.

The disadvantages for LOHT, supportive oral cryotherapy is that it is regimen-specific efficacy, because it is not universally applicable across chemotherapy types and tolerability varies. Cold-triggered adverse symptoms may be relevant for some agents (e.g., oxaliplatin) per certain protocols, requiring regimen-specific decision-making.

With regard to DPT using cryonics as a frozen ice-ball for testing tooth-pulp vitality, positive reactions are common, but no reaction is unreliable, and other techniques, like electricity tests, are needed to confirm non-vital pulps. The definitive pulp-test, is to drill a small cavity towards the pulp, the reaction to which (pain) will reflect vitality. A non-vital pulp will not induce pain. The test cavity in vital teeth can easily be permanently restored whereas in non-vital teeth, the cavity can be used for endodontics.

Concluding Remarks

Cryonics in Oral/Dental cryotherapy is pragmatically classified for three applications and/or interventions: (1) *Ablative cryosurgery, (ACS)*, reported variable evidence, with a strong mechanistic rationale; ACS is best for clearly diagnosed, well-selected lesions with follow-up, (2) *Supportive oral cryotherapy for LOHT*,

and (3) *Dental pulp-testing. (DPT)* Many different designs and application devices are available for use of freezing produced from liquid gases.

The Future and Alternate Applications in Dentistry

The use of cryonics and/or cryotherapy may well be exploited in the future for other therapeutic orodental purposes, as has been suggested to use ACS liquid injections to stop growth of developing wisdom teeth follicles, as a prophylaxis against third molar impactions and consequent sequelae from infections and surgical morbidity.¹⁸ Another future application of cryonics can be for immediate cryopreservation of extracted teeth (like a full set of four third-molars), to be used as material for auto-bone-grafting material when needed later in the patients life.¹⁹ Cryopreservation is a critical technique in biological research, enabling the long-term, viable storage of living cells and soft tissues at ultra-low temperatures (typically -80°C to -196°C). Often viable oral tissue is excised in dento-alveolar and/or periodontal surgery; these tissues could be rapidly frozen and be a valuable source of human cells for future use. The cells are placed in carefully prepared liquids which ensure survival of deep freezing. This procedure stops cellular metabolism, permitting vital tissue cells to be kept for long periods; after thawing the cells retain their viability with vital functions and genetic codes for future use of live cellular biomedical research.^{20,21}

Conclusion

Oral Cryotherapy is a proven, evidence based, successful treatment modality for oral benign soft tissue lesions. It is an essential tool in Oral Medicine that should be part of all modern Dental Clinics that provide Oral Health Care.

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This study did not involve human participants, and therefore, informed consent was not required

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This research does not involve any clinical trials.

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The sole author was responsible for the conceptualization, methodology, data collection, analysis, writing, and final approval of the manuscript

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