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Cold relieves pain - Cryotherapy in Endodontics

[1]Mukta Bansal, Senior Lecturer, Department of Conservative Dentistry & Endodontics, Rama Dental College, Hospital & Research Centre, Kanpur ,India

[2]Saurav Paul, Senior Lecturer, Department of Conservative Dentistry & Endodontics, Rama Dental College, Hospital & Research Centre, Kanpur ,India

[3]Ayushi Khanna, Post Graduate Student, Department of Conservative Dentistry & Endodontics, Rama Dental College, Hospital & Research Centre, Kanpur, India

[4]Virginia Vizo, Post Graduate Student, Department of Conservative Dentistry & Endodontics, Rama Dental College, Hospital & Research Centre, Kanpur, India

Corresponding Author: Mukta Bansal, Senior Lecturer, Department of Conservative Dentistry & Endodontics, Rama Dental College, Hospital & Research Centre, Kanpur, India.

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Abstract

Introduction: The aim of this review study was to examine the concept of cryotherapy, its process, physiological effects, and many uses in endodontics.

Conclusions: Cryotherapy is a concise and affordable adjunct treatment for lowering postoperative pain in cases of symptomatic apical periodontitis and limiting pulpal hemorrhage during critical pulp therapy. It is, without a doubt, a vital step for managing post-endodontic surgery swelling and discomfort. Further study is needed, however, to evaluate the effect of cryogenic treatment on newer generations of nickel-titanium rotary instruments.

Keywords: Cryotherapy, Cryogenic Treatment of Nickel-Titanium, Cold Therapy, Cryotherapy In Endodontics.

Introduction

Cryotherapy is the technique of reducing tissue temperature for therapeutic purposes. The phrase comes from the Greek words "cryos" (cold) and "therapeia" (cure)[1].As early as 3000 BCE, the ancient Egyptians used ice to cure injuries and decrease inflammation. Nonetheless, James Arnott was the first to record and demonstrate the use of a salt-ice combination in malignant sickness in 1851. [2].

Cryotherapy is used to treat a wide range of musculoskeletal as well as neurological disorders. According to both physiological and clinical data, cold treatment in various forms appears to be useful in lowering musculoskeletal pain, muscle spasm, connective tissue distensibility, nerve conduction velocity, haemorrhage, edoema, inflammation, and intramuscular temperature. [1,2]

Cryotherapy involves transferring heat from a higher-temperature tissue to a lower-temperature subject rather than cooling the target tissue.[3]. Cryotherapy is commonly utilized in medical and other dental areas. [4].

Physiological Effect of Cryotherapy

The majority of healthcare providers tend to find pain treatment to be the most challenging problem. Greater postoperative discomfort is related with root canal treatment than with other dental operations.[5]. As a result, in endodontic practise, postoperative pain control is crucial. According to Hargreaves and Hutter, postoperative discomfort is to be expected, especially in teeth with prior pain and/or pulp necrosis. [6]. Symptomatic apical periodontitis is the most prevalent cause of postendodontic discomfort. It is analogous to any other connective tissue's usual acute inflammatory reaction.[7]It includes vasodilation, increased vascular permeability, and leukocyte transmigration from blood arteries to the site of tissue damage. Neutrophils and macrophages make the enormous bulk of migratory leukocytes. Inflammatory mediators initiate these biological activity, resulting in tissue damage, discomfort, and edoema. [8, 9]. Postendodontic discomfort can be prevented in clinical practise by taking precise steps during the endodontic protocol and conducting each clinical phase with greatest accuracy. Long-term anaesthetic and occlusal reduction have also been suggested as pain-relieving methods. [10]. Drugs can be administered prior to or following surgery to produce preoperative analgesia or to regulate pain. Such drugs include nonsteroidal anti-inflammatory drugs, paracetamol, and corticosteroids. While they are reasonably safe medications, they can cause adverse effects such as gastrointestinal intolerance. [11-13] and renal, hepatic, and respiratory disorders have been reported [14]. Lasers and cryotherapy have been proposed as treatments to avoid these adverse effects[15]. The principal physiological tissue effects of cryotherapy include vascular, neurologic, and tissue metabolism. When subjected to cold for more over 15 minutes, tissue has an initial reflex vasoconstriction followed by cold-induced vasodilation. The histamine-like chemical "H" is released and facilitates vasodilation. The following passage of heated blood induces vasoconstriction succeeded by vasodilation in the region. The "hunting response" refers to the repeated and continuous loop of vasoconstriction and vasodilation. [16]. Vasoconstriction is a neurological reaction activated by the adrenergic components of blood arteries that occurs after vasodilation and reduces vascular permeability, drawing the cell wall together. [17]. Decreased permeability is crucial in minimizing the quantity of fluid seeping into periradicular tissue as exudate or transudate, and therefore in reducing tissue edoema and edoema, which are prevalent in periapical tissue following chemo mechanical treatment. Avoiding a postsurgical hematoma following periradicular surgery is crucial not only for pain management, but also for optimizing healing, minimizing the frequency of postsurgical problems, and improving outcomes.Cold treatment after surgery lowers local blood flow and inhibits the rebound phenomena that happens following the administration of vasoconstrictor-containing local anaesthetics. As a result, cold administration to the surgical field is now the standard practise for postoperative supportive treatment. In terms of neurologic impact, analgesia is intimately connected to

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the nerve conduction velocity of nociceptive sensory nerve fibres. [19,20].Cooling produces analgesia by lowering nerve conduction velocity.[21]

This impact is stronger in myelinated nerve fibres (A-delta fibres) than in unmyelinated fibres (C fibres), since the former is totally deactivated at approximately 7 C, whilst the latter is completely deactivated at around 3 C, as Franz and Iggo demonstrated.[22] It has also been claimed that gate control theory is crucial for cryotherapy's analgesic action by giving quicker sensory input by the bigger myelinated A fibres to momentarily shut the gate and block the propagation of the more painful unmyelinated C fibre impulses.[23]. Furthermore, cold treatment may promote analgesia by boosting their release of neuroactive substances such as endorphins. Endorphins attach to opioid sites in the medullary dorsal horn, inhibiting the transmission of nociceptive impulses to the central nervous system. [24]. Additionally, cold treatment may reduce overall activation threshold of tissue nociceptors (specialised nerve endings that respond in response to tissue damage), resulting in cold induced neuropraxia, a local anaesthetic effect. [25]. Hence, the analgesic effect of cooling is achieved by a combination of slowed brain pain signal propagation and reduced pain mediator release. In terms of cryotherapy's effect on tissue metabolism, wounded tissue uses more oxygen, leading to tissue hypoxia and necrosis. Cryotherapy lowers tissue blood flow and cell metabolism considerably. As a result, the pace of metabolic responses decreases, limiting free radical formation in tissues, decreasing oxygen consumption, and avoiding tissue hypoxia and additional tissue harm. [26,27]. Endodontic treatment includes the use of cryotherapy. Cryotherapy was originally highlighted in the realm of endodontics by Vera et al28. They used a final rinse of 2.5 C cold saline mixed with Endovac (Kerrdental, KerrHawe SA, Bioggio, Switzerland) for five mins of application time to assess the temperature change of the external root surface of removed teeth. They detected a 4 minute drop in outer root surface temperature of more than 10 degrees Celsius. They recommended more clinical study using the same methodologic framework, expecting that lowering root surface temperature would result in a local anti-inflammatory and analgesic impact on periapical tissue. In 2016, Keskin et al29 employed cryotherapy in endodontic treatment for the first time to minimise postoperative discomfort following single-visit root canal therapy.[28] Vera et al. suggested utilising a side-vented, positive-pressure 31-G NaviTip needle (South Jordan, Utah) rather than negative apical pressure to counteract its further influence on postoperative pain. According to the findings of this study, the cryotherapy group saw a marked decrease in postoperative complications when compared to the control group. Their study comprised teeth with inflamed pulp. Their study included teeth with severely inflamed pulps, but they didn't differentiate among asymptomatic and symptomatic pulpitis, or those with and without apical periodontitis.

Noncategorization, nondifferentiation, and examining a broad pool may have impacted the results since the level of inflammation and the level of preoperative discomfort surely effect the frequency and degree of postoperative pain. According to previous trials that followed the same technique as Vera et al., cryotherapy decreased postoperative discomfort following single-visit root canal therapy in teeth with important pulps.[28]. However, in irreversible pulpitis, where the inflammation is confined within the pulp and doesn't extend into the periapical tissue, removal of a inflamed pulp is typically accompanied by patient comfort, so the

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real effect of cryotherapy on reducing post - operative pain could not be established in this case.Cryotherapy was also used to reduce postoperative pain in irreversible pulpitis with and without apical periodontitis. A final rinsing of cold saline was applied with a 27-G sidevented needle. Cryotherapy primarily had an impact in patients with apical periodontitis, although there wasn't a substantial variation in the frequency of postoperative pain between both the cryotherapy group as well as the control group in patients with just irreversible pulpitis. [32]. Alharthi et al. discovered that cryotherapy was ineffective in formerly asymptomatic instances lacking periapical pathosis. [33].

This was consistent with the findings of Jain et al. [34], who also recommended using cryotherapy to reduce postoperative pain only in cases of symptomatic irreversible pulpitis with apical periodontitis.

In cases of symptomatic apical periodontitis, Emad et al. (Thesis, 2020) examined the impact of various irrigation methodologies on postoperative pain and interleukin 6 expression. All irrigation protocols that used 2–5 mL cold irrigant had significantly lower pain scores than those that used room temperature irrigation. Moreover, interleukin 6 expression was lowest after irrigation with 2–5 mL of cold sodium hypochlorite first from beginning to the end of cleaning and shaping.Cryotherapy has been widely used in endodontics to reduce postoperative pain, according to numerous studies. Cryotherapy has lately become more widely employed in endodontic vital pulp treatment, where it was successfully used in a case report to prevent pulpal haemorrhage during direct pulp capping. For 60 seconds, chopped distilled water ice (0 C) was directly applied to exposed pulp tissue and the whole tooth surface, then eliminated by high-suction aspiration and irrigated with EDTA.Finally, the exposed area was sealed with a bioceramic material and permanently restored. After two weeks, the treated teeth were asymptomatic and remained asymptomatic, vital, and functional for the next 12-18 months. More clinical trials are needed to determine the long-term outcome of vital pulp cryotherapy. Topçuoglu et al[35] recently evaluated the influence of preoperative intraoral cryotherapy on the rate of success of inferior alveolar nerve blocks. They found that, especially in teeth with symptomatic irreversible pulpitis, intraoral cryotherapy increased the effectiveness of inferior alveolar nerve blocks. To produce thorough pulpal anaesthesia, however, it may frequently be essential to use additional anaesthesia procedures.

Effects of Cryotherapy on Endodontic Instruments

The most important step in root canal therapy is biomechanical preparation[36]. Particularly in significantly curved canals, the invention of NiTirotary tools has substantially improved, allowing for more faster and more easy preparation with very few shaping flaws.[37-42]. Nevertheless, NiTi rotary instruments' cutting surfaces may develop surface flaws during the machining process, increasing wear and the sensitivity to corrosion.[43]. Instruments made of NiTi have a lower microhardness (303-362 Vicker hardness number) than those made of stainless steel (522-542 Vicker hardness number)[44]. The combination of surface wear and decreased microhardness decreases the cutting effectiveness of NiTi instruments when contrasted to stainless steel instruments.[45].Moreover, these machining flaws may serve as a site of stress concentration for surface crack propagation and eventual fracture.[46].The unanticipated separation of rotary tools during instrumentation is a significant barrier to successful root canal therapy. Flexural fracture (cycle fatigue fracture) and torsional fracture are the two

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fracture mechanisms recognised for NiTi instruments. When the file tip becomes trapped in the apical region during instrument rotation, ductile fracture and torsional fatigue failure can occur.[46,47].Contrarily, cyclic fatigue failure results from repeated phase transformations between the austenitic and martensitic phases of NiTi, which causes cyclic fatigue and fracture coined with brittle fracture whenever it exceeds the unrecoverable plastic deformation state. This ongoing switching among intense compressive and tensile stresses inside a curved root canal is what causes cyclic fatigue and failure. Approximately to 90percent of total of fractures are caused by this mechanism.[48,49]. To increase the cutting effectiveness, cyclic fatigue resistance, and wear resistance of rotary files, a number of surface treatment techniques have been suggested. One of them is boron.

Ion implantation[50], thermal nitridation[51], titanium nitride physical vapour deposition[52], electropolishing, and cryogenic treatment are some of the techniques used. Cryogenic treatment of metals during manufacturing has historically been recommended to increase the metals' surface hardness and thermal durability.[53]It is an additional process that entails first freezing superelasticNiTi and stainless steel before gradually bringing the metal to room temperature.[54-56]. Shallow cryogenic therapy and deep cryogenic treatment are categories based on the treatment temperature. At about 280 C, conventional subzero treatments have been undertaken (shallow cryogenic treatment). The instrument's lifespan is increased even further by lower temperature treatments (deep cryogenic treatments), such as those produced by liquid nitrogen at 2185 C and 2196C.Whenever the material is submerged in liquid nitrogen, the procedure is regarded as being wet. A dry procedure means that the material is held just above liquid nitrogen level but is not submerged. The dry deep cryogenic treatment (DCT) offers the benefit of gently raising or lowering the temperature to prevent thermal shock, which would cause the instrument to become brittle.[57]. Deep cryogenic treatment has advantages over shallow cryogenic treatment in terms of increased cutting efficiency, overall metal strength[58], and the release of internal alloy stresses as a result of cryogenic treatment-induced plastic transformation[59]. Cryogenic treatment, unlike surface treatment techniques, affects the entire cross section of the metal rather than just the surface[54]. Cryogenic therapy may thus be useful for enhancing the strength of rotary endodontic files. In order to explain why some qualities improve following cryogenic treatment, several methods have been put forth. They include (1) the creation of titanium nitride on the surface as a result of an interaction between nitrogen and titanium atoms.[60], (2) Nitrogen atom deposition into the interstitial gaps of the NiTi alloy's atomic lattice, creating lattice strain[61], (3) a more thorough martensitic transition of the NiTi alloy's austenite phase[59], and (4) precipitation of finer carbide particles throughout the crystal lattice[55]. The latter two mechanisms have been proposed to explain cryogenic changes in steel alloys[59]. Because there is no carbon in the NiTi alloy, the fourth mechanism is immediately ruled out[38].There is disagreement over which mechanisms is to blame. In the endodontic literature, two research on cryogenic therapy on stainless steel endodontic implements have been published.Cryogenic treatment had no effect on the cutting efficiency of stainless steel endodontic instruments (Flex R files; Midwest Dental Equipment & Supply, Oklahoma City, OK and Hedstr€om files; Kerrdental, KerrHawe SA, Bioggio, Switzerland), according to Bramipour et al. [62], whereas Berls[63] discovered no significant

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increase in wear resistance of stainless steel hand instruments (S-type and K-type). According to Vinothkumar et al., cryogenic treatment of extremely elastic NiTi files considerably boosted cutting efficiency without reducing wear resistance.[57]. This dispute might be attributed to the type and timing of cryogenic treatment. The former immersed the instruments entirely in liquid nitrogen for 10 minutes, while the later employed dry DCT therapy for 24 hours. Dry DCT treatment considerably enhanced cyclic fatigue resistance of superelasticNiTi files as compared to untreated files. The full changeover of the alloy's austenitic phase to the martensitic phase, which may have happened around 2195 C and therefore lowered internal stresses inside the alloy owing to plastic deformation, was linked to the positive improvement in cycle fatigue.

An alloy's remaining austenite phase decreases hardness and tool wear resistance.[41]. Thus, the most important benefit of using cryogenic treatment is increased wear resistance and reduced internal stresses[64].Yazdizadeh et al. [65] discovered no improvement in cycle resistance after totally immersing the files in 2196 C for 24 hours, contradicting the good impact of dry DCT on the cyclic fatigue resistance of rotating NiTi files. The crystalline structure and austenite finish temperature of endodontic NiTi alloys separate them into two categories. The first set of instruments is primarily in the austenite phase at body temperature (conventional superelasticNiTi, M-Wire, and Rphase).

They exhibit superelastic characteristics due to the stress-induced martensite transition and tend to spring back to their original shape following deformation[66,67]. The other recently disclosed set of NiTi instruments exists largely in the martensite phase at body temperature (CM-Wire and Gold and Blue heat-treated NiTi files). These martensitic instruments were easily deformed and display a shape memory effect when warmed due to the reconfiguration of the martensite variations.When compared to austenitic alloy, martensitic alloy produces more flexible instruments, better cycle fatigue resistance, and a higher angle of deflection.[68]. Notwithstanding the great flexibility of this latest group[69], further cryogenic treatment was undertaken in an attempt to enhance the amount of martensite and improve cycle fatigue resistance and cutting efficiency, especially with smaller instruments. At 2185 C, DCT was employed with two distinct immersion durations (24 hours and 6 hours). During a 24-hour soak period, DCT enhanced cycle fatigue resistance by 13%, but just 1% after a 6-hour immersion time. Nevertheless, the amount of time spent soaking had no influence on cutting efficiency[70]. This might be attributed to a lack of time for the full transition of residual austenite to martensite[71].

Conclusion

Cryotherapy may be stated to be a simple and low-cost adjunct treatment for lowering postoperative pain in apical periodontitis and managing pulpal bleeding during critical pulp therapy. It is, without a doubt, a crucial step in endodontic surgery for minimising postsurgical swelling and discomfort. Further investigation is required to determine the impact of cryogenic treatment on the recently heat-treated NiTi rotary instrument.

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