CRYOTHERAPY IN THE FIELD OF ENDODONTICS: A LITERATURE REVIEW

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1. INTRODUCTION

Root canal treatment is a daily need therapy in dental practice. The main rationale for root canal therapy is to provide a favorable environment for the healing of peri-radicular tissues, by applying a proper chemo-mechanical disinfection to eliminate micro-organisms for establishing obturation with hermetic seal (Gade et al., 2020). Different chemical and mechanical injuries could be associated with endodontic treatment that may lead to postoperative pain or other complications (Muaddi et al., 2023). New therapies are emerging in the endodontic field to deliver the best treatment that improves the patient’s experience (Gade et al., 2020).

Cryotherapy is an emerging approach as an anti-inflammatory therapy (Muaddi et al., 2023). It deals with treatment at reduced temperature (Vats & Jathanna, 2020). Cryotherapy is a term originated from Greeks where cryos stand to “cold” and therapy stand to “cure”, which explains it as therapy by lowering the tissue temperature (Balasubramanian & Vinayachandran, 2017). As early as 2500 BCE, Ancient Egyptians were the first to treat inflammation and lesions by low temperature (Fayyad et al., 2020). It was used for more than 50 years to control pain (Vats & Jathanna, 2020). After applying cryotherapy, there will be reduction in the blood flow and the metabolic activity with neural receptors inhibition associated with increased oxygen diffusion in the injured tissue (Muaddi et al., 2023). The alteration in tissue and temperature magnitude is related to the difference between heat or cold application, time of exposure, tissue thermal conductivity, object temperature and the agent used whether ice or gel pack, ice chips, packaged chemical ice pack or melted ice water used to apply the cold (Gade et al., 2020).

This therapy is used in different fields of medicine including neurology, traumatology, physiotherapy, orthopedics, plastic, maxillofacial and oral surgery, and recently in the field of endodontics (Vats & Jathanna, 2020).

The field of endodontics applies cryotherapy in different procedures mainly to reduce postoperative pain and inflammation (Al-Abdullah et al., 2020). It was primarily used as irrigant during root canal treatment and after peri-radicular surgery (Vats & Jathanna, 2020). Recently, it is used for hemostasis in vital pulp therapy (Fayyad et al., 2020).

The aim of this review is to point out the different and recent clinical applications of cryotherapy in the field of endodontics and to mention its physiology and its effect regarding postoperative pain and inflammation concerning the presented literature.

2. METHODOLOGY:
The review is based on articles reviewed from the electronic search of PubMed, Scopus, ScienceDirect and EBSCO databases. The search used four keywords: Cryotherapy – Root canal treatment – Endodontic postoperative pain – Cold saline, resulting in three hundred seven records. Additional records were identified from other sources using the same keywords giving two hundred seventy-six records. All the records were added together to remove the duplicates ending with four hundred forty-nine records that were screened for eligibility after checking the titles, resulting in fifty-five records, another fourteen articles were excluded being not relevant to the aim of the review after screening their abstracts to end up with a total of forty-one articles.

The forty-one articles were assessed for eligibility to exclude seven articles that were not related to the application of cryotherapy in the field of endodontics where some discussed different...
irrigation techniques and different procedures to decrease the endodontic postoperative pain and others mentioned the effect of anesthesia without being related to cryotherapy. At the end, five more articles were excluded due to unavailability of the full text.

The search for the review ended up with twenty-nine full text articles that were checked for being relevant to the topic and so a flowchart illustrated summarizing the methodology (as shown as Fig. 1).

3. RESULTS

The search that was applied from different databases resulted in five articles reviewing the literature about cryotherapy mentioning its different implications in endodontics. Four other articles were systematic reviews about the effect of cryotherapy on endodontic postoperative pain.

The search also included fifteen randomized clinical trials that studied how cold saline as final irrigant may affect the postoperative pain following root canal treatment, where twelve trials were applied on vital teeth and two were for necrotic teeth. Some studies were selective regarding the apical tissue condition that showed the effect of cryotherapy relative to normal or symptomatic apical periodontitis. One clinical trial was done to study the influence of cryotherapy on the pro-inflammatory and the anti-inflammatory mediators in teeth with apical periodontitis.
An in-vitro study determined that temperature of the root surface will be reduced by more than 10 degrees Celsius for 4 minutes when cold saline is used for irrigation applied to the apical third of the canal inducing the anti-inflammatory effect on the apical tissues.

Two other in-vitro studies demonstrated that cryotherapy may negatively affect the fracture resistance of the root.

The search also included a clinical study regarding the effect of cryotherapy as supplementary procedure on inferior alveolar nerve block. As well as one more clinical trial about the vital pulp cryotherapy.

4. DISCUSSION

Cryotherapy is a recent therapeutic option applied in different medical fields for postoperative care and pain management (Keskin et al., 2017). It is considered a new form of therapy where the body will be exposed to a very low (cold) temperature promoting healing and other advantages (Al-Nahlawi et al., 2016).

In relation to many studies, the literature suggests that cryotherapy is an easy, low cost, painless and non-irritating procedure to control postoperative pain after root canal treatment (Keskin et al., 2017).

The effectiveness of cryotherapy in the dental field depends on its mechanism, where the application of cold on the tissues result in decreased temperature due to subtracting heat from them, leading to reduced cell metabolism decreasing their use of oxygen thus lowering the blood flow, following is vasoconstriction limiting the damage to tissues (Keskin et al., 2017) (Prithviraj et al., 2021). In addition, it influences the peripheral nerve endings by reducing the threshold required to activate the tissue nociceptors and the painful nerve impulses speed (Vera et al., 2018).

The primary use of cryotherapy in dentistry was after peri-radicular surgery to allow vasoconstriction at the surgery site then during root canal treatment as a final irrigant to reduce the postoperative pain (Agarwal et al., 2021). This results from reduction in the surface temperature of the root (Vera et al., 2015). Besides, fracture resistance of the tooth will be reduced by the cold application of solution in the canal (Keskin et al., 2019).

The most recent use of cryotherapy is in vital pulp therapy where ice shavings help in hemorrhage control of the pulp and allowing vasoconstriction (Bahcall J. et al., 2019).

In this review, the complete mechanism and physiology of cryotherapy on tissues will be discussed with shedding light on its use in root canal treatment with its clinical aspects along with its side effects regarding the current available literature.

4.1. Physiology of Cryotherapy

The application of cold or heat result is three main physiological responses in the body: 1) decrease or increase in local blood flow, 2) decrease or increase in cellular metabolic activity, and 3) inhibition or stimulation of skin and subcutaneous tissues neural receptors (Balasubramanian & Vinayachandran, 2017). As stated by Van’t Hoff’s law, cryotherapy limits the biomechanical reactions due to vasoconstriction and reduction in the cellular metabolism which minimizes the tissue
damage thus reduces the cells oxygen demand limiting the tissue production of free radicles (Balasubramanian & Vinayachandran, 2017).

Concerning the vascular response, once the tissue is exposed for more than 15 minutes to low temperature, vasoconstriction will occur as initial reflux followed by cold induced vasodilation, this cycle is continuous and repetitive known as “hunting response” (Fayyad et al., 2020). Vasoconstriction following vasodilation is triggered by the blood vessels adrenergic elements which reduces the vascular permeability (Fayyad et al., 2020). This reduced permeability is the key factor in decreasing the leakage of fluid into peri-radicular tissues as exudate that occurs during biomechanical preparation thus limiting edema and swelling of the tissue and thus pain (Agarwal et al., 2021). Another effect of the cold application is the prevention of hematoma, that explains its use postsurgical, where following the vasoconstrictor local anesthesia helps to hinder the local blood flow and offset the rebound phenomenon (Fayyad et al., 2020).

Concerning the neurologic response, pain is related to the speed of nerve conduction of the nociceptive nerve fibers (Agarwal et al., 2021). The low temperature slows down the velocity of nerve conduction inducing analgesia (Fayyad et al., 2020). According to Franz and Iggo, complete deactivation of myelinated A-δ fibers occurs when temperature reaches about 7°C and deactivation of nonmyelinated C-fiber occurs at about 3°C (Franz D. & Iggo A., 1968).

Concerning the tissue metabolism, any injured tissue will consume more oxygen resulting in hypoxia and necrosis (Fayyad et al., 2020). The application of cryotherapy lowers the blood flow and metabolism of tissue by more than 50%, thus impedes the biomechanical reactions, hindering the formation of free radicles in the tissues reducing oxygen consumption and thus hypoxia and necrosis of the tissues (Nadler et al., 2004).

4.2. Effect of cryotherapy on endodontic postoperative pain

Postoperative pain is a common complication following root canal treatment (Al-Abdullah et al., 2020). The prevalence of endodontic postoperative pain arrays between 1.5% and 53% (Sadaf et al., 2020). Cryotherapy has a dynamic role in decreasing inflammation and pain by vasoconstriction (Jaiswal et al., 2020). The use of cold saline as final irrigant following complete biomechanical preparation of the canals will induce reduction in the localized temperature thus diminishing the cellular metabolism that in turns affect the endings of the peripheral nerves by fading the required threshold to stimulate the painful nerve impulses and tissue nociceptors (Jain A. et al., 2021). Pain receptors “thermoreceptors” are temperature sensitive nerve endings that are affected by change in temperature of tissues as cryotherapy may block their nociception decreasing pain (Al-Nahlawi et al., 2016).

Keskin et al. suggested that the use of 2.5 degrees Celsius saline as final irrigant for 5 minutes decrease the postoperative pain when applied on vital teeth (Keskin et al., 2017). This was also concluded by Prithviraj et al. that uses the same temperature of saline (Prithviraj et al., 2021). And the same was reported by Al-Abdullah et al. (Al-Abdullah et al., 2020).

Al-Nahlawi et al. advocated the use of cold saline to decrease the endodontic postoperative pain along with the use of negative pressure irrigation (EndoVac) that promotes less debris extrusion and thus affect the postoperative pain (Al-Nahlawi et al., 2016). However, Bazaid & Kenawi et al. showed from his randomized clinical trial that endodontic postoperative pain is only reduced by cold
saline in cases of irreversible pulpitis along with symptomatic apical periodontitis but not reduced if normal apical tissues are present (Bazaid & Kenawi, 2018).

A study of Alharathi et al. showed that final irrigation with cold or room temperature saline lowers the postoperative pain which is in accordance to results of Keskin et al. and Al-Nahalwi et al. that showed also significant decrease of pain while using cold saline (Alharthi et al., 2019) (Keskin et al., 2017) (Al-Nahlawi et al., 2016).

Regarding necrotic pulp, Jaiswal et al. reported no effect of using cold saline of 2.5 degrees Celsius for 5 minutes on postoperative pain in cases of symptomatic apical periodontitis (Jaiswal et al., 2020). In contrast, Vera et al. reported a decrease in postoperative pain regarding the same cases (Vera et al., 2018).

4.3. Effect of cryotherapy on periapical inflammation

Endodontic treatment may induce inflammation of the periapical tissues (Vats & Jathanna, 2020). This will result in raised local temperature (Vats & Jathanna, 2020). Vera et al. concluded from their in-vitro study that the application of cold saline decreases the root surface temperature more than 10 degrees Celsius maintaining it for 4 minutes which is enough to induce confined anti-inflammatory effect on the peri-apical tissues (Vera et al., 2015). However, they suggested that cold saline must be applied by negative pressure irrigation device to allow it to reach the apical third of the root (Vera et al., 2015).

Mourad et al. suggested that the application if intracanal cryotherapy induces lower levels of pro-inflammatory mediators (interleukin-10) and higher levels of anti-inflammatory mediators (interleukin-1β) in cases of apical periodontitis (Mourad et al., 2021).

4.4. Effect of cryotherapy in vital pulp therapy

Vital pulp therapy is indicated in teeth diagnosed with reversible or irreversible pulpitis in selected cases (Vats & Jathanna, 2020). Removal of the inflamed pulpal tissue will result in bleeding which is commonly controlled by sodium hypochlorite (Cao et al., 2015). However, sodium hypochlorite affects negatively the viability of pulpal stem cells when applied in high concentrations on the pulp affecting the regenerative process of the dentin-pulp complex (Martin et al., 2014). In addition, irrigation with EDTA improves the release of growth factors from dentin that are needed for regeneration but when applied with the use of sodium hypochlorite it reduces such release (Galler et al., 2015). For this, vital pulp cryotherapy was introduced recently for hemorrhage control after removal of the inflamed pulp tissues (Gade et al., 2020).

Bahcall J. et al. showed successful results of vital pulp cryotherapy. They applied shaved sterile water ice of 0 degrees Celsius over the exposed pulp tissue to control bleeding for one minute, then removed with high suction and irrigation with 17% EDTA, then the cavity was filled with bioceramic followed by placing final restoration. The cases remained vital, functional, and asymptomatic after 18 months (about 1 and a half years) of follow-up (Bahcall J. et al., 2019).

This approach still requires more studies to determine its long-term prognosis.
4.5. Effect of cryotherapy on Inferior Alveolar Nerve Block

Topçuoğlu et al. conducted a study on mandibular molar with symptomatic irreversible pulpitis where they concluded that cryotherapy is considered an adjunct procedure for the success of inferior alveolar nerve block in cases of symptomatic irreversible pulpitis (Topçuoğlu et al., 2019). Cryotherapy was done by placing intraorally on the vestibular surface of the selected tooth small ice packs for five minutes (Topçuoğlu et al., 2019). The results are due to the fact of the analgesic effect produced by the low temperature, where cryotherapy tempts the local anesthetic effect by lowering the pain signals conduction velocity and nociceptors activation threshold (Topçuoğlu et al., 2019).

4.6. Effect of cryotherapy on fracture resistance

Thermal change is a source of mechanical stress on the tooth (Jain S et al., 2020). The stress magnitude depends on different factors including difference in temperature between tooth and medium, geometry of tooth, coefficient of heat transfer, and physical properties of tooth as aging and mechanical stress (Keskin et al., 2019). The application of cold solution in the pulp space may cause more thermal stress on the dentin structure due to absence of enamel and dentin tubular microstructure that are close to pulp space (Agarwal et al., 2021).

Keskin et al. and Jain S et al. suggested that cryotherapy decreases the vertical fracture resistance of teeth (Keskin et al., 2019) (Jain S et al., 2020).

However, the results of these two trials are limited as they are conducted on extracted teeth. Such results are confined to specific conditions that differ from the in-vivo studies such as the oral environment, temperature, PDL and vital tissues surrounding the teeth that may affect the outcome of the study.

Although cryotherapy is decent in controlling postoperative pain when used in root canal treatment, however it is reducing the fracture resistance of the tooth, and this requires more clinical studies regarding the survival rate of such teeth (Jain S. et al, 2020).

5. CONCLUSION

Cryotherapy is a recent approach evolving in the field of endodontics. It is a simple and elementary procedure applied in different clinical implications that showed positive outcomes relative to the literature. It is effective in reducing endodontic postoperative pain and inflammations as well as controlling intra pulpal bleeding cases of vital pulp therapy procedures. More clinical and experimental studies are needed to reach a thorough knowledge and facts regarding the application of such therapy in endodontics.

REFERENCES
- Al-Abdullah, A., Al-Marrawi, K., & Abdullah, A. (2020). Comparative study to investigate the effect of cryotherapy on post-operative pain using two different preparation techniques (In vivo


