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APPLICATIONS OF COLD IN ENDODONTICS

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ABSTRACT Historically cryotherapy, the application of cold for treatment has been used to manage pain and inflammation. Its role in medicine and dentistry is well established while its applications in endodontics is promising. This review is aimed to cover the aspects of cold applications in endodontics such as in manufacture of endodontic files, diagnosis and therapeutics especially during root canal treatment.

KEYWORDS : Cryotherapy, endodontic irrigation, cryogenic treatment, post endodontic pain.

INTRODUCTION

The word "Cryos" meaning cold or ice cold (Belitsky et al., 1987) has been used as a therapeutic modality as early as 2500 BCE by the Egyptians to treat injuries and inflammation. Therapies using low and very low temperatures (-190 C to -78.5 C) is popular in the field of medicine for the management of pain, inflammation, skin and mucosal diseases (Koç et al., 2006; Kwekkeboom, 2001; Watkins et al., 2014). Therapeutic applications of cold in dentistry is well established but recently there is a renewed interest in the field of endodontics owing to its benefits and significant favorable outcomes. The aim of this review is to discuss the various applications of cold in different aspects of endodontics such as in

1.Manufacture of instruments
2.Diagnostics
3.Therapeutics

1. Manufacture Of Endodontic Instruments – Cryogenic Treatment

NiTi files are manufactured by machining due to which surface flaws occur which, coupled with inherent lower surface hardness of the alloy can lower cutting efficiency (Thompson, 2000). Thermomechanical and surface treatment of endodontic files have been tried to improve the properties of the NiTi alloy (Linu et al., 2017). Cryogenic treatment, a two-step process affects the entire cross-section of the alloy rather than just the surface and its effects are described as follows (Bensely et al., 2005).

1)Microhardness

Cryogenic treatment of NiTi files immersed in liquid nitrogen at -196 °C for '1 h per 1 inch. of cross-section' followed by a 10 minute time period to reach ambient room temperature resulted in a statistically significant increase in microhardness(Kim et al., 2005).

2)Cutting Efficiency

The impact of dry Cryogenic treatment (-185C) on NiTi instrument was considerable improvement in the cutting efficiency but no effect on wear resistance. (Vinothkumar et al., 2007)

3)Cyclic Fatigue

While one study did not show any improvement in the cyclic fatigue resistance of NiTi files after cryogenic treatment (Sabet et al., 2020) another study found that deep dry cryo-treated NiTi files have a higher cycle fatigue resistance than untreated NiTi file due to an increase in hardness resulting from a complete transitioning from the austenitic to the martensitic phase. This could be due to a drop in the level of internal stress due to plastic deformation (George et al., 2011).

1. Diagnostic Application Of Cold In Endodontics

Cold as a pulp test has been used as early as 2500BC (Rand et al., 1968). It is a more accurate pulpal test than the heat test (Shabahang & American Association of Endodontics Research and Scientific Affairs Committee, 2005). Cold test is usually combined with Electric pulp testing, both of which assess the conduction of the A delta fibres of the pulp. Nevertheless the true value of any testing can be obtained only when combined with all the clinical findings and radiography (Rotstein & Ingle, 2019)

Principle: When cold stimulus is applied to the enamel of the tooth or on the restoration, the temperature of the tooth is reduced. An outward movement caused by the contraction of the fluid produces a strong response in the A delta fibres (hydrodynamic theory). (Brannstrom & Johnson 1970). Repeated application of cold is refractory as the fluid displacement rate reduces causing a less painful response (Bender, 2000).

In a normal pulp, pain disappears a few seconds after removal of the stimulus whereas diseased pulp can respond as immediate, severe pain on application of the cold stimulus / a lingering or severe pain after the stimulus is removed/ no response to the stimulus (Pitt Ford & Patel, 2004).A necrotic pulp could possibly not respond to cold but could relieve the pain produced by a heat stimulus (Berman et al., 2010).

Materials Used For Cold Testing:

Ice: Ice has been used by freezing water in local anaesthetic cartridges and then applying the extruded portion to the tooth. Since the ice melts quickly, they can be felt in adjacent teeth and gingiva making it an unreliable, impractical test.

Dry ice sticks(carbon dioxide, CO_2 – 78C): Dry ice sticks is the most reliable cold test to use in most diagnostic situations and in patients with crowns (Chen & Abbott, 2011).It is also the cheapest and quickest method of testing the pulp's reaction to a cold stimulus. The dry ice "stick" placed on the tooth surface or restorative surface produces an effective temperature of about – 56°C. (Peters et al., 1986)

Refrigerant sprays: Tetrafluoroethane or a mixture of gases (e.g., propane/butane/isobutane) has largely replaced Ethyl chloride, dichlorodifluoromethane due to environmental concerns. Tetrafluoroethane(−26°C) has an effective temperature of −18.5°C, while the propane/butane/isobutane mixture temperature (−50°C) produces an effective temperature of −28°C on the tooth (Peters et al., 1986). They have to be sprayed on a cotton pellet for every tooth tested as they evaporate quickly. They are generally less effective than dry ice, especially when testing teeth with porcelain crowns.

3.Therapeutic Application Of Cold In Endodontics

Cryotherapy works on three basic physiological reactions which occur in tissues when heat or cold is applied to them namely vascular response, neuronal response, and a change in tissue metabolism (Balasubramanian & Vinayachandran, 2017).

i) *Vascular response*: The initial response in the first 20-30 mins of cold application is marked by vasoconstriction, after which a "Lewis hunting reaction or **hunting response**" sets in which is characterized by vasodilatation due to flow of blood through arteriovenous anastomoses. The application of cold post operatively for short durations has benefits because it causes vasoconstriction, reduces haemorrhage, perfusion of fluids and ultimately results in decreased oedema. Accordingly, ice should be applied for 10 mins and removed for 20 mins (1:2 ratio) to reduce the hunting response (Forsgren et al., 1985; Greenstein, 2007; Kwon et al., 1986).

ii) *Neuronal response*: Analgesia is induced by reducing the speed of nerve conduction of nociceptive nerve fibers (Algafly et al., 2007). Cryotherapy blocks nociception in the spinal cord by activating thermoreceptors, which have temperature-sensitive nerve endings. Myelinated A-fibers, non-myelinated C-fibers which are primarily responsible for oral pain transmission get deactivated completely at 7°C and 3°C respectively (Franz & Iggo, 1968).

iii) *Tissue metabolism*: Oxygen demand rises as a result of hypoxia tissue damage and necrosis. Cryotherapy reduces tissue blood flow and slows metabolism by nearly half, slows down the rate of oxygen consumption and biochemical responses , limits free radical generation in tissues and prevents additional tissue damage (Nadler et al., 2004).

The clinical effect of the cryotherapy depends on the extent of the temperature change, biophysical changes in the tissues which is in turn determined by a number of parameters, including temperature differences between the object and cold application, exposure length, tissue thermal conductivity, and the type of thermal agents used (Hubbard & Denegar, 2004).

a) Cryotherapy for local anesthesia

Preoperative intraoral cryotherapy improved the efficacy of inferior alveolar nerve blocks (IANBs) in patients with symptomatic irreversible pulpitis by providing a local anesthetic effect by lowering nociceptors' activation thresholds and pain signal conduction speeds.(Topçuoğlu et al., 2014).

Refrigerated 2% lignocaine HCl with 1:100,000 epinephrine in maxillary molars with symptomatic irreversible pulpitis served as an effective alternative to conventional anaesthesia for achieving success, reduced pain, and faster onset during endodontic treatment (Gurucharan et al., 2022).

b) Cryotherapy for Vital pulp therapy:

Cryotherapy helped prevent hemorrhage from the inflamed pulp during direct pulp capping. Shaved sterile water ice (0°C) was placed for one minute over the direct or roundabout entrance of the pulpal tissue alongside the entire tooth, and the liquified ice was removed with high-speed suction after which the exposed pulp was irrigated with 17% EDTA and bioceramic material was used to repair it. Over the next 12 to 18 months, it was discovered that teeth remained asymptomatic, vital and functional (Bahcall et al., 2019). More clinical investigations are needed to assess the long-term prognosis of cryotherapy in vital pulp therapy.

c)Cryotherapy for Endodontic Irrigation

Nearly 3 to 58% of patients suffer from post endodontic pain **(PEP)** (Sathorn et al., 2008) whose physiology is similar to that of a classic acute inflammatory reaction. Vasodilation occurs after injury, resulting in enhanced permeability and subsequent transmigration of leukocytes (neutrophils and macrophages). These inflammatory episodes produce tissue damage resulting in discomfort and edema (Blicher et al., 2017). Intracanal cryotherapy by cooling irrigants such as saline, sodium hypochlorite and EDTA were studied as follows.

Cryotreated Saline

Vera et al. introduced the use of cryotherapy by using cold saline (2.5°C) as a final and found this innovative approach decreased and maintained the outside root surface temperature by >10°C for at least 4 minutes. This procedure was supposed to have an anti-inflammatory response in the periradicular tissues (Vera et al., 2015).Based on these interesting findings a clinical trial to evaluate the impact of 2.5°C cold saline irrigation as a last irrigant on patients with symptomatic irreversible pulpitis (Keskin et al., 2017a) and found to produce significant reduction in post-operative pain levels. A trial among asymptomatic patients found comparable reduction in pain levels in room temperature saline and cryotreated saline used as a last irrigant (Alharthi et al., 2019).The effect of intracanal cryotherapy with negative irrigation also reduced postoperative pain in patients with irreversible pulpitis with apical periodontits (Al-Nahlawi et al., 2016; Bazaid & Kenawi, 2018) and so did similar studies (Al-Abdullah et al., 2020; Vera et al., 2018; J. P. Vieyra et al., 2019) at 6, 24, 48 hrs (Jain et al., 2018). Extraoral, intraoral, and intracanal cryotherapy on patients undergoing root canal treatment for symptomatic irreversible pulpitis reported a greater reduction in postoperative pain on days 1, 3, 5, and 7 than those in the control group (Sadaf, 2019).

Cryotreated sodium hypochlorite:

The antimicrobial activity of cryotreated sodium hypochlorite showed a significant reduction in the number of *E. faecalis* compared to normal sodium hypochlorite. (Mandras et al., 2013). Patients had reduced postoperative pain and reduced analgesic intake at 6 h postoperatively(Nandakumar & Nasim, 2020) when canals were irrigated with 20 ml cryotreated sodium hypochlorite(2°C–4°C) for 5 min.

Cryotreated EDTA

Irrigation with cryotreated 17% EDTA and saline solution reduced the occurrence of post endodontic pain and need for medication (J. Vieyra et al., 2019).

Advantages Of Intracanal Cryotherapy

- Reduces post-operative endodontic pain after 6 h and 24 h after Root Canal Therapy (Sadaf et al., 2020)
- Reduces the usage of drugs after endodontic treatment. (Gundogdu & Arslan, 2018)
- Significant bacterial reduction especially E fecalis with cryotreated NaOCl when compared to standard NaOCl irrigation.(Mandras et al., 2013).
- Simple and cost effective Disadvantages of intracanal cryotherapy
- Fracture strength in the intracanal cryotherapy group was significantly lower, it reduced the vertical fracture resistance of prepared roots.(Keskin et al., 2017b)

- The negative effects of reduced temperature on somatic tissues should be considered in a clinical scenario. Further exposure to reduced temperature might lead to hypoxia, acidosis, arteriolar and venular thrombosis and ultimately ischaemic necrosis of the tissues in contact(Gurucharan et al., 2017).
- More clinical trials required.

Cryotherapy For Post Endodontic Surgery Care:

The application of ice pack with moderate pressure on the outside of the face (20 min on, 5 min off) for 4-6 hrs after endodontic surgery aids in reducing pain and post-operative swelling (Fayyad et al., 2020; Rotstein & Ingle, 2019).

CONCLUSION

The value addition of cold in the manufacture of endodontic instruments, diagnostic testing and therapeutics show great promise in the branch of endodontics. Cryotherapy as an adjunct therapy in intracanal, intraoral or extraoral applications shows significant potential for pain relief in post endodontic pain. More clinical research on the prospective benefits of this simple, cost-effective treatment modality in situations when pain and inflammation are expected must be conducted for justifying regular clinical use.

REFERENCES

1. Al-Abdullah, A., Abdullah, A., & Al-Marrawi, K. (2020). Comparative study to investigate the effect of cryotherapy on post-operative pain using two different preparation techniques (In vivo study). *International Journal of Applied Dental Sciences*, *6*, 163–168.
2. Algafly, A. A., George, K. P., & Herrington, L. (2007). The effect of cryotherapy on nerve conduction velocity, pain threshold and pain tolerance * Commentary. *British Journal of Sports Medicine*, *41*(6), 365–369. https://doi.org/10.1136/bjsm.2006.031237
3. Al-Nahlawi, T., Hatab, T. A., Alrazak, M. A., & Al-Abdullah, A. (2016). Effect of Intracanal Cryotherapy and Negative Irrigation Technique on Postendodontic Pain. *The Journal of Contemporary Dental Practice*, *17*(12), 990–996.
4. Bahcall, J., Johnson, B., & Xie, Q. (n.d.). Introduction to vital pulp cryotherapy. *Endod Pract US 2019;1:14*.
5. Balasubramanian, S., & Vinayachandran, D. (2017). *Cryotherapy"-A Panacea for Post-Operative Pain Following Endodontic Treatment*.
6. Bazaid, D. S., & Kenawi, L. M. M. (2018). The Effect of Intracanal Cryotherapy in Reducing Postoperative Pain in Patients with Irreversible Pulpitis: A Randomized Control Trial. *International Journal of Health Sciences*, *2*, 6.
7. Belitsky, R. B., Odam, S. J., & Hubley-Kozey, C. (1987). Evaluation of the Effectiveness of Wet Ice, Dry Ice, and Cryogen Packs in Reducing Skin Temperature. *Physical Therapy*, *67*(7), 1080–1084. https://doi.org/10.1093/ptj/67.7.1080
8. Bender, I. B. (2000). Pulpal pain diagnosis—A review. *Journal of Endodontics*, *26*(3), 175–179. https://doi.org/10.1097/00004770-200003000-00012
9. Bensely, A., Prabhakaran, A., Mohan Lal, D., & Nagarajan, G. (2005). Enhancing the wear resistance of case carburized steel (En 353) by cryogenic treatment. *Cryogenics*, *45*(12), 747–754. https://doi.org/10.1016/j.cryogenics.2005.10.004
10. Berman, L. H., Hargreaves, K. M., & Cohen, S. R. (2010). *Cohen's Pathways of the Pulp Expert Consult*. Elsevier Health Sciences. http://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=1430210
11. Blicher, B., Pryles, R. L., & Lin, J. (2017). Endodontics Review A Study Guide. *Stomatology Edu Journal*, *4*(3), 227. https://doi.org/10.25241/stomaeduj.2017.4(3).bookreview.4
12. Chen, E., & Abbott, P. V. (2011). Evaluation of accuracy, reliability, and repeatability of five dental pulp tests. *Journal of Endodontics*, *37*(12), 1619–1623. https://doi.org/10.1016/j.joen.2011.07.004
13. Fayyad, D. M., Abdelsalam, N., & Hashem, N. (2020). Cryotherapy: A New Paradigm of Treatment in Endodontics. *Journal of Endodontics*, *46*(7), 936–942. https://doi.org/10.1016/j.joen.2020.03.019
14. Forsgren, H., Heimdahl, A., Johansson, B., & Krekmanov, L. (1985). Effect of application of cold dressings on the postoperative course in oral surgery. *International Journal of Oral Surgery*, *14*(3), 223–228. https://doi.org/10.1016/s0300-9785(85)80032-6
15. Franz, D. N., & Iggo, A. (1968). Conduction failure in myelinated and non-myelinated axons at low temperatures. *The Journal of Physiology*, *199*(2), 319–345. https://doi.org/10.1113/jphysiol.1968.sp008656
16. George, G. K., Sanjeev, K., & Sekar, M. (2011). An in vitro evaluation of the effect of deep dry cryotreatment on the cutting efficiency of three rotary nickel titanium instruments. *Journal of Conservative Dentistry: JCD*, *14*(2), 169–172. https://doi.org/10.4103/0972-0707.82627
17. Greenstein, G. (2007). Therapeutic efficacy of cold therapy after intraoral surgical procedures: A literature review. *Journal of Periodontology*, *78*(5), 790–800. https://doi.org/10.1902/jop.2007.060319
18. Gundogdu, E. C., & Arslan, H. (2018). Effects of Various Cryotherapy Applications on Postoperative Pain in Molar Teeth with Symptomatic Apical Periodontitis: A Preliminary Randomized Prospective Clinical Trial. *Journal of Endodontics*, *44*(3), 349–354. https://doi.org/10.1016/j.joen.2017.11.002
19. Gurucharan, I., Saravana Karthikeyan, B., & Mahalaxmi, S. (2017). Intracanal cryotherapy in endodontics. *Australian Endodontic Journal*, *43*(3), 138–139. https://doi.org/10.1111/aej.12206
20. Gurucharan, I., Sekar, M., Balasubramanian, S., & Narasimhan, S. (2022). Effect of precooling injection site and cold anesthetic administration on injection pain, onset, and anesthetic efficacy in maxillary molars with symptomatic irreversible pulpitis: A randomized controlled trial. *Clinical Oral Investigations*, *26*(2), 1855–1860. https://doi.org/10.1007/s00784-021-04160-8
21. Hubbard, T. J., & Denegar, C. R. (2004). Does Cryotherapy Improve Outcomes With Soft Tissue Injury? *Journal of Athletic Training*, *39*(3), 278–279.
22. Keskin, C., Özdemir, Ö., Uzun, İ., & Güler, B. (2017a). Effect of intracanal cryotherapy on pain after single-visit root canal treatment. *Australian Endodontic Journal*, *43*(2), 83–88. https://doi.org/10.1111/aej.12175
23. Keskin, C., Özdemir, Ö., Uzun, İ., & Güler, B. (2017b). Effect of intracanal cryotherapy on pain after single-visit root canal treatment. *Australian Endodontic Journal*, *43*(2), 83–88. https://doi.org/10.1111/aej.12175
24. Kim, J. W., Griggs, J. A., Regan, J. D., Ellis, R. A., & Cai, Z. (2005). Effect of cryogenic treatment on nickel-titanium endodontic instruments. *International Endodontic Journal*, *38*(6), 364–371. https://doi.org/10.1111/j.1365-2591.2005.00945.x
25. Koç, M., Tez, M., Yoldaş, O., Dizen, H., & Göçmen, E. (2006). Cooling for the reduction of postoperative pain: Prospective randomized study. *Hernia: The Journal of Hernias and Abdominal Wall Surgery*, *10*(2), 184–186. https://doi.org/10.1007/s10029-005-0062-2
26. Kwekkeboom, K. L. (2001). Pain management strategies used by patients with breast and gynecologic cancer with postoperative pain. *Cancer Nursing*, *24*(5), 378–386. https://doi.org/10.1097/00002820-200110000-00009
27. Kwon, H. J., Rhee, J. G., Song, C. W., & Waite, D. E. (1986). Effects of temperature on blood flow in facial tissues. *Journal of Oral and Maxillofacial Surgery: Official Journal of the American Association of Oral and Maxillofacial Surgeons*, *44*(10), 790–793. https://doi.org/10.1016/0278-2391(86)90155-2
28. Linu, S., Lekshmi, M. S., Varunkumar, V. S., & Sam Joseph, V. G. (2017). Treatment Outcome Following Direct Pulp Capping Using Bioceramic Materials in Mature Permanent Teeth with Carious Exposure: A Pilot Retrospective Study. *Journal of Endodontics*, *43*(10), 1635–1639. https://doi.org/10.1016/j.joen.2017.06.017
29. Mandras, N., Allizond, V., Bianco, A., Banche, G., Roana, J., Piazza, L., Viale, P., & Cuffini, A. M. (2013). Antimicrobial efficacy of cryotreatment against *Enterococcus faecalis* in root canals. *Letters in Applied Microbiology*, *56*(2), 95–98. https://doi.org/10.1111/lam.12017
30. Nadler, S. F., Weingand, K., & Kruse, R. J. (2004). The physiologic basis and clinical applications of cryotherapy and thermotherapy for the pain practitioner. *Pain Physician*, *7*(3), 395–399.
31. Nandakumar, M., & Nasim, I. (2020). Effect of intracanal cryotreated sodium hypochlorite on postoperative pain after root canal treatment—A randomized controlled clinical trial. *Journal of Conservative Dentistry: JCD*, *23*(2), 131–136. https://doi.org/10.4103/JCD.JCD_65_20
32. Peters, D. D., Mader, C. L., & Donnelly, J. C. (1986). Evaluation of the effects of carbon dioxide used as a pulpal test. 3. In vivo effect on human enamel. *Journal of Endodontics*, *12*(1), 13–20. https://doi.org/10.1016/S0099-2399(86)80276-X
33. Pitt Ford, T. R., & Patel, S. (2004). Technical equipment for assessment of dental pulp status. *Endodontic Topics*, *7*(1), 2–13. https://doi.org/10.1111/j.1601-1546.2004.00063.x
34. Rand, R. W., Rinfret, A. P., & Von Leden, H. (1968). *Cryosurgery*. CC Thomas.
35. Rotstein, I., & Ingle, J. I. (Eds.). (2019). *Ingle's endodontics* 7. PMPH USA.
36. Sabet, Y., Shahsiah, S., Yazdizadeh, M., Baghamorady, S., & Jafarzadeh, M. (2020). Effect of deep cryogenic treatment on cyclic fatigue resistance of controlled memory wire nickel-titanium rotary instruments. *Dental Research Journal*, *17*(4), 300. https://doi.org/10.4103/1735-3327.292069
37. Sadaf, D. (2019). Limited Quality Evidence Suggests that Application of Cryotherapy May Be Helpful in Reducing Postoperative Pain in Root Canal Therapy in Patients With Symptomatic Apical Periodontitis. *The Journal of Evidence-Based Dental Practice*, *19*(2), 195–197. https://doi.org/10.1016/j.jebdp.2019.05.005
38. Sadaf, D., Ahmad, M. Z., & Onakpoya, I. J. (2020). Effectiveness of Intracanal Cryotherapy in Root Canal Therapy: A Systematic Review and Meta-analysis of Randomized Clinical Trials. *Journal of Endodontics*, *46*(12), 1811-1823.e1. https://doi.org/10.1016/j.joen.2020.08.022
39. Sathorn, C., Parashos, P., & Messer, H. (2008). The prevalence of postoperative pain and flare-up in single- and multiple-visit endodontic treatment: A systematic review. *International Endodontic Journal*, *41*(2), 91–99. https://doi.org/10.1111/j.1365-2591.2007.01316.x
40. Shabahang, S. & American Association of Endodontics Research and Scientific Affairs Committee. (2005). State of the art and science of endodontics. *Journal of the American Dental Association (1939)*, *136*(1), 41–52; quiz 89–90. https://doi.org/10.14219/jada.archive.2005.0025
41. Thompson, S. A. (2000). An overview of nickel-titanium alloys used in dentistry. *International Endodontic Journal*, *33*(4), 297–310. https://doi.org/10.1046/j.1365-2591.2000.00339.x
42. Topçuoğlu, H. S., Demirbuga, S., Tuncay, Ö., Pala, K., Arslan, H., & Karataş, E. (2014). The Effects of Mtwo, R-Endo, and D-RaCe Retreatment Instruments on the Incidence of Dentinal Defects during the Removal of Root Canal Filling Material. *Journal of Endodontics*, *40*(2), 266–270. https://doi.org/10.1016/j.joen.2013.07.024
43. Vera, J., Ochoa, J., Romero, M., Vazquez-Carcaño, M., Ramos-Gregorio, C. O., Aguilar, R. R., Cruz, A., Sleiman, P., & Arias, A. (2018). Intracanal Cryotherapy Reduces Postoperative Pain in Teeth with Symptomatic Apical Periodontitis: A Randomized Multicenter Clinical Trial. *Journal of Endodontics*, *44*(1), 4–8. https://doi.org/10.1016/j.joen.2017.08.038
44. Vera, J., Ochoa-Rivera, J., Vazquez-Carcaño, M., Romero, M., Arias, A., & Sleiman, P. (2015). Effect of Intracanal Cryotherapy on Reducing Root Surface Temperature. *Journal of Endodontics*, *41*(11), 1884–1887. https://doi.org/10.1016/j.joen.2015.08.009
45. Vieyra, J., Enriquez, F., Acosta, F., & Guardado, J. (n.d.). *Reduction of Postendodontic Pain after One-visit Root Canal Treatment Using Three Irrigating Regimens with Different Temperature*. 7.

46. Vieyra, J. P., J Enriquez, F. J., Acosta, F. O., & Guardado, J. A. (2019). Reduction of postendodontic pain after one-visit root canal treatment using three irrigating regimens with different temperature. *Nigerian Journal of Clinical Practice*, *22*(1), 34–40. https://doi.org/10.4103/njcp.njcp_349_18
47. Vinothkumar, T. S., Miglani, R., & Lakshminarayananan, L. (2007). Influence of Deep Dry Cryogenic Treatment on Cutting Efficiency and Wear Resistance of Nickel–Titanium Rotary Endodontic Instruments. *Journal of Endodontics*, *33*(11), 1355–1358. https://doi.org/10.1016/j.joen.2007.07.017
48. Watkins, A. A., Johnson, T. V., Shrewsberry, A. B., Nourparvar, P., Madni, T., Watkins, C. J., Feingold, P. L., Kooby, D. A., Maithel, S. K., Staley, C. A., & Master, V. A. (2014). Ice packs reduce postoperative midline incision pain and narcotic use: A randomized controlled trial. *Journal of the American College of Surgeons*, *219*(3), 511–517. https://doi.org/10.1016/j.jamcollsurg.2014.03.057