Review Article

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Hilotherapy in Oral and Maxillofacial Surgery

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ABSTRACT

Background: Craniomaxillofacial surgical procedures regardless of the operative techniques, have facial pain and oedema as the most common postoperative sequelae restricting the function. In the present era, there has been a significant increase in newer innovations in medicine in lieu of demand for high grade medical services as a result of health consciousness among people and improved quality of life, becoming the choice for majority. Given the increasing importance of enhanced recovery after surgery, combined use of analgesics and anti-inflammatory drugs as the therapy of choice for relieving pain and edema have been described in literature and practiced since long time. In addition to drug therapies, compression bandages, massage therapy and cryotherapy have also been used. Cryotherapy is the application of ice packs to decrease local temperature. Recently, a new technique has been introduced as Hilotherapy which utilizes water cooled mask for postoperative pain and swelling, has been shown to be more effective than standard cryotherapy. The purpose of this review article is to evaluate the effectiveness and various applications of hilotherapy in craniomaxillofacial procedures.

Keywords: Hilotherapy, cryotherapy, pain, oedema, maxillofacial surgery.

INTRODUCTION

Irrespective of whether the surgical procedure is minor or major, facial pain, edema, inflammation and limited mouth opening due to muscle spasm (trismus) are the most common postoperative sequelae in craniomaxillofacial surgery.[1] Pain is typically brief and reaches its peak intensity in the early postoperative period, whereas facial swelling reaches its maximum intensity 24-48 hours postoperatively.[2]

These symptoms can affect the patients' quality of life. Several pharmacological means of therapy like corticosteroids, NSAIDS or enzyme preparations like serratiopeptidase, can be used to reduce or eliminate these symptoms. Similarly, various non-pharmalogical methods, such as local compression, soft laser, manual lymph drainage and cryotherapy can also be used.[3,4,5]

Man has known the use of cold for analgesia for thousands of years. The ancient Egyptians documented the use of low temperature for analgesia. Hippocrates (460-377 BC), records of the use of ice for pain relief, describing how snow was brought down from the mountains in ancient Greece and applied to wounds for pain relief. Avicenna of Persia (980-1070 AD) an early physician, described the use of cold for pre-operative analgesia. Arnott described the use of severe cold to treat pain in 1848, and by 1851, he was avidly promoted the application of cold to relieve certain types of cancer and nerve pain, using mixtures of ice and salt at –20ºC. He also noted the

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hemostatic and anesthetic effects of such a mixture. Richardson introduced ether spray in 1866 for topical anesthesia, which was followed by ethyl chloride spray in 1891. Thus "to freeze" became synonymous with "to numb". Modern cryoanalgesia traces its roots to Cooper et al. who developed in 1961 a device that used liquid nitrogen in a hollow tube that was insulated at the tip and achieved a temperature of –190ºC.[6]

However, Cryotherapy, is a general term which describes the application of topical ice at the site of injury and which tries to avoid the extremely low temperatures used in cryosurgery, thereby avoiding the detrimental effects of "freezing". It has become one of the commonest mode of treatment in immediate management of acute soft injury.[6] Cryotherapy/cold therapy causes vasoconstriction of the precapillary arterioles, decreased tissue perfusion and diminution of metabolic reactions. Temperatures between 12.8^{0}C – 15.6^{0}C and 13.6^{0}C - 27^0 C is estimated to be most effective in reducing edema and pain respectively.[7,8,9] The common methods of cryotherapy have been icepacks or gels which usually decrease in efficacy as the temperature of icepack begins to rise on longer application. Hilotherapy is recently introduced controlled continuous cooling method with the help of water circulating in anatomically shaped mask.

Numerous studies and reviews exist on the effects of cold therapy but, because of the methodological differences between previous studies, comparison of their results difficult. The present review aims to add to the literature on hilotherapy while examining the currently available literature to provide a critical assessment directed at enumerating the usefulness of the procedure in maxillofacial surgery.

PHYSIOLOGICAL EFFECTS OF CRYOTHERAPY

Temperature Changes

Cryotherapy does not convey cold to tissues because cold is not transferable. Heat is transferred between molecules from warmer to cooler areas, deeper structures lose heat to more superficial tissues that were cooled.[10] Ebrall et al. in 1989, demonstrated that skin temperatures were reduced to 12 ^{0}C, 9.9 ^{0}C, and 7.3 ^{0}C after a 15-minute application of wet ice, dry ice, or cryogen, respectively. No change in skin warmth was found 1cm proximal or medial to an ice pack.[11]

In another study, Ebrall et al. in 1992, reported a decrease in skin warmth from 37 ^{0}C to 7.6 ^{0}C within 5 minutes and to 5 ^{0}C within 10 minutes using a wet ice pack.[12] Enwemeka et al.[13] and Myrer et al.[14] indicated that thick tissues experienced less penetration of cold and it took longer to cool subjacent structures.

Hemodynamics (blood flow)

Cold application initially resulted in vasoconstriction of blood vessels which results in reduced hemorrhage and perfusion of fluids, and ultimately less edema.[15]

Kwon et al. found that 20 minutes of ice to the cheek was necessary to reduce buccal mucosal blood flow. Intraoral irrigation with cold water (11^{0}C) did not alter blood flow in oral and facial tissues besides the tongue.[16]

Edema

As a result of injury (i.e., surgery), fluid leaves the cells because of increased osmotic pressure, resulting in edema though it may be caused by hemorrhage.[17] The greatest amount of swelling after oral surgery was recorded at different time points: 19 to 24 hours, second postoperative day, or after 48 to 72 hours.[15]

Decreased temperature reduces tissue metabolism and permeability, which metabolism results in less tissue debris resulting in fewer mediators, a diminished amount of free protein, and, subsequently, less osmotic pressure for fluid to exit cells, thereby less edema.[18]

Pain Reduction

Decreased pain was caused by cold-induced diminished nerve conduction velocity with blockage of sensory fibers before motor fibers.[19] Stillwell demonstrated that conduction velocities were reduced 0.4 mm/sec per ^{0}C of cooling.[15] The critical temperature at which alterations of nerve velocity commenced was 27^{0}C[8], and analgesia began after skin temperature was decreased to 13.6^{0}C (tested with a pin prick)[9]. De Jong et al. indicated that nerve transmission ceased between 9 ^{0}C and 18^{0}C.[20]

Metabolic Processes

Reducing tissue temperature suppresses injured tissue's metabolic rate and enzymatic processes.[21] Zachariassen reported that a decrease of 10^0C resulted in a 50% reduction in enzymatic metabolic processes. To diminish skin metabolic rates, the temperature needed to be around 10^0C.[22]

CONTRAINDICATIONS FOR COLD THERAPY

Hypertension (due to secondary vasoconstriction); Raynaud's disease (blood vessels in extremities may experience extreme constriction during ice therapy); rheumatoid arthritis; local limb ischemia; history of vascular impairment, such as frostbite or arteriosclerosis; cold allergy (cold urticaria); paroxysmal cold hemoglobinuria; cryoglobulinemia; or any disease that produces a marked cold pressor response.[15]

MODES OF COLD APPLICATION

Cryotherapy includes numerous techniques to induce heat abstraction e.g., ice pack, ice massage, gel pack, ice chips in a plastic bag, ice in a washcloth, ice wrapped in a paper towel, prepacked chemical ice packs and melted ice water through wet towels.[23,24] The main differences are as follows: freezing mixture (ice, frozen gel, frozen mixture of water and alcohol); details of application (whether to place an ice pack directly on the skin) & timing of application and duration of treatment.

DISADVANTAGES WITH THE TRADITIONAL COOLANTS:

Conventional cryotherapy has some drawbacks, partly due to the patient, partly due to the method. Patients often disregard the intervals of time of application and cannot continue the application when they sleep (night interruption). The correct placement of the ice pack is neither controllable nor constant, and patient cooperation might be poor. Moreover, ice pack cannot provide uniform heat conduction. What is well known is that rapid changes in temperature and extreme low temperatures should be avoided. It is also apparent that cryotherapy should start early after injury at temperatures between 10 ^{0}C and 15 ^{0}C. Patients undergoing conventional cryotherapy might incur different adverse effects: damage from hypothermia, vasodilatation caused by block of nerve conduction, paralysis of the contractile mechanism of the vascular walls, and intense perception of cold.[15]

Unlike traditional cryotherapy, therapy with Hilotherm is not subject to interruptions (possibility to keep the mask during the night); it is not affected by the state of consciousness or the cooperation of the patient and ensures a uniform temperature distribution on the involved soft tissues.

HILOTHERAPY

A new equipment for cryotherapy at constant temperature (Hilotherm, Argenbu¨hl-Eisenharz, Germany) has recently been introduced.[25] It consists of a polyurethane mask connected to a circuit in which the coolant flows (demineralized water). The masks provided with the device are modeled to fit the different regional anatomies (Fig. 1)

Fig 1: Equipment for cryotherapy

Therapeutic process: As a thermal healing process, hilotherapy acts on the affected parts of the body through hypothermia. The applied temperatures are set to the nearest degree in a range between +10 to +30 ^{0}C depending on the indication. It is based on a closed loop circulatory system where water flows through anatomically fitted cuffs applied to specific part of body requiring treatment.[25]

Benefits: faster healing, decreased hemorrhage, reduced swelling, relieves pain within a short time, reduced need for analgesics and steroids, easy to use, enhances patient comfort with high level of acceptance.

Indications: traumatology, orthopedics, oral and maxillofacial surgery, plastic and esthetic surgeries, vascular and microsurgery, flap surgery, sports medicine and general postoperative healing and physiotherapy. General therapeutic uses: oedema, pain reliefs, hematoma, muscle strains, inflammatory arthritis.

DISCUSSION

Cold therapy is a simple method that has traditionally been used to reduce pain and swelling after acute musculoskeletal injuries and various orthopedic surgical procedures. Cryotherapy reduces local temperature (between 10 ^{0}C and 15^{0}C). It has different effects on postoperative edema and decrease of the cellular metabolism that allows the cells to survive with less oxygen consumption and less secondary hypoxic damage & vasoconstriction that reaches its maximum intensity at 15^{0}C. There is reduction of the microvascular permeability and leakage of macromolecules & decrease of the conduction speed of peripheral motor and sensory nerves that causes reduction of local pain and muscle spasm.[15]

The traditional cryotherapy application protocols differ in timing and types of application. Some authors suggest applying ice packs directly on the skin, whereas other authors propose to apply oil on the skin or a cloth between the skin and the ice pack to prevent injury from hypothermia. Different authors propose a variety of administration timings and also compared the efficacy of intermittent therapy to continuous therapy, leading to contradictory results.

The most widely used protocol is the ice pack application at intervals of 10 to 20 minutes for 48 to 72 hours, but there is no clear evidence about the most effective cryotherapy protocol.

Unlike traditional cryotherapy, therapy with Hilotherm is not subjected to interruptions (possibility to keep the mask during the night); it is not affected by the state of consciousness or the cooperation of the patient and ensures a uniform temperature distribution on the involved soft tissues. Application temperature can be chosen between 10 ^{0}C and 30 ^{0}C. The preshaped polyurethane mask adapts easily to the morphology of the patient and restricts the hypothermic effect to the areas affected by injury. It also ensures uniform cooling and avoids abrupt temperature gradients.[26]

In the published orthopaedic literature, there is a plethora of studies including evidence-based research on the effect of cold therapy in reducing the complications after various orthopedic procedures. However, despite the long history of cold therapy in the management of the postoperative sequelae of impacted tooth surgery, the effectiveness of this modality has not been sufficiently evaluated and the results of previous studies are not consistent. In studies per-formed by Van der Westhuijzen et al.[27], Forouzanfar et al.[28], and Nusair[29], it was found that the application of cold had no beneficial effect on reducing the sequelae of dentoalveolar surgeries. However, in the study by Forouzanfar et al., only pain was evaluated, and in the animal study by Nusair, only facial swelling was evaluated. In contrast, an intra-individual, randomized clinical trial by Laureano Filho et al. demonstrated that cold therapy reduced the oedema and pain but not the trismus after surgery. Nevertheless, the sample size in this latter study was small and the authors recommended further related research. A study by Rana et al.[22] showed that cooling therapy using the Hilotherm system was more effective than the conventional method in reducing the sequelae of third molar surgery. In previous investigations evaluating the effectiveness of cold therapy in minimizing the problems after dentoalveolar procedures, different cooling devices (ice bags, Hilotherm, chemical packs, etc.), cold therapy protocols (e.g., the initiation and duration of cold application), and study designs have been used.[30]

It is safe to report that the pain-relieving effect of cold therapy is rather well documented. Considering the literature in oral and maxillofacial surgery there is a paucity of scientific evidence of trials that show either positive or negative effects of cold therapy (Van der Westhuijzen et al., 2005). As well as positive effects, negative side effects have been described such as tissue injuries, disturbances of lymph drainage and microcirculation or chilblains.

Based on the available literature the applications of hilotherapy/Hilotherm can be enumerated as follows-

APPLICATIONS IN ORAL AND MAXILLOFACIAL SURGERY

Hilotherapy uses a prefabricated, facially contoured, polyurethane mask to channel a current of cool water adjacent to skin to provide regulated cryotherapy perioperatively.

I. Orthognathic surgery:

Belli et al. in 2009[26] used Hilotherapy system, as a cooling and compression system, at fixed temperature and adjustable for cutaneous tissues, to prevent post-surgery complications. It was applied in a recovery room for 10 patients who underwent LeFort I osteotomy and bilateral sagittal split osteotomy at a temperature of 15^0C for the first 24hours. They reported that with the use of the Hilotherapy system, the swelling and pain decreased in intensity and time, allowing a quicker path to recovery of mandibular dynamics, a better comfort for patients, and an easy management of patients by medical attendants.

Tahim A et al. and Dillon et al. studied the effects of hilotherapy in patients who underwent bimaxillary osteotomies on the postoperative length of stay. They concluded that mean length of hospital stay decreased significantly after the introduction of hilotherapy mask.

II. Trauma

Rana M et al.[33] compared postoperative cooling therapy using cold compresses with water circulating cooling face mask by Hilotherm. In their study, 32 patients assigned for treatment of bilateral mandibular fractures and were divided randomly into treatment either with the Hilotherm cooling face mask or with conventional cooling with cooling compresses. Cooling was initiated as soon as possible after surgery until the 3rd postoperative day and applied continuously for 12 h daily. Facial swelling was quantified by a 3D optical scanning technique. Pain, neurological complaints,mandibular dysfunction and the degree of mouth opening were measured for each patient.

The authors concluded that patients receiving cooling therapy by Hilotherm demonstrated less facial swelling, less pain, a tendency to fewer neurological complaints and were more satisfied when compared to conventional cooling. The authors noted that Hilotherm is more superior in the management of postoperative swelling and pain after treatment of bilateral mandibular fractures when compared to conventional cooling.

III. Facial malformations

Moro et al.[7] evaluated the effectiveness of this equipment in controlling postoperative edema and compared the results with those obtained with a group treated with conventional cryotherapy and a group not treated with cryotherapy. Hilotherm was more effective in containing edema than the ice pack. According to these authors, Hilotherm granted better and faster recovery of mandibular function, greater comfort, and easier patient management by the nursing staff. The treatment consisted in the greater reliability of the Hilotherm system, which is characterized by easy handling, constant temperature control, comfort, and practicality of the masks.

IV. Facial esthetic surgery:

1. **Rhinoplasty [25]**
2. **Facelift**

Jones et al., conducted a randomized controlled trial which demonstrated Hilotherapy is effective in cooling the face after SMAS based facelift surgery and suggested Hilotherapy may find a place in the management of patients after subperiosteal facial surgery.[34]

V. **Benign tumor excision[25]**

CONCLUSION

Facial pain, oedema, and ecchymosis characterize the postoperative sequelae of a range of craniomaxillofacial procedures, including oral surgery, orthognathic surgery, facial fracture management, and aesthetic facial surgery. Given the increasing importance of enhanced recovery after surgery (ERAS) and emphasis on patient-reported outcome measures (PROMs), hilotherapy may provide a means to reduce the postoperative convalescent period by reducing pain and swelling, whilst avoiding the side effects of conventional analgesia.

According to the currently available literature, cryotherapy with Hilotherm has proven an effective aid, superior to application of ice packs, which is characterized by easy handling, constant temperature control, comfort, and practicality of the masks. This allows starting cryotherapy immediately after surgery avoiding sudden changes in temperature, excessive hypothermia, or damage by freezing; Hilotherm can also be applied regardless of patient's cooperation.

Some of the conclusions that can be drawn from this review are –

- hilotherapy was more effective than cold compression simply due to differences in surface contact with the contoured hilotherapy mask applied across a wider area.
- standard cryotherapy is likely to vary in temperature (becoming warmer over time), which hilotherapy does not.
- more patient satisfaction as once applied, the hilotherapy mask does not have to be manipulated, unlike standard cold compression gel packs, which required replacement.

The substantial difference between different treatments probably consisted in the greater reliability of the Hilotherm system. However, inspite of the prevalent use of cold therapy/hilotherapy via Hilotherm after dentoalveolar procedures, the efficacy of this treatment requires further investigation.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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