# "THE EFFECTIVENESS OF PHOTOBIOMODULATION USING 940 NM DIODE LASER FOR REDUCING PAIN, SWELLING AND TRISMUS AFTER THIRD MOLAR SURGERY: A SINGLE BLINDED RANDOMIZED CONTROL TRIAL."


**By**

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**REG.NO. – IF0219002**


# *Dissertation*

*Submitted to the*
*KLE Academy of Higher Education & Research Belagavi, Karnataka*
*In partial fulfillment of the requirements for the degree of*

**MASTER OF DENTAL SURGERY**

**In**

**ORAL AND MAXILLOFACIAL SURGERY**

**(BRANCH III)**

**Under the guidance of**
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**Professor**


**DEPARTMENT OF ORAL AND MAXILLOFACIAL SURGERY**
**KAHER's V K INSTITUTE OF DENTAL SCIENCES**
**BELAGAVI, KARNATAKA**


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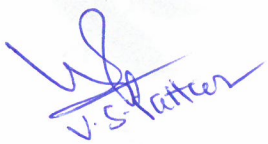

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***Dr. Radhika Pathak***

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| Pre-op | : | Preoperative |
| Post-op | : | Postoperative |
| LLLT | : | Low Level Laser Therapy |
| PBM | : | Photobiomodulation |

# ABSTRACT

**Introduction**

One of the most common procedures done worldwide in the field of oral and maxillofacial surgery is the extraction of third molars- impacted or otherwise[1]. As with all surgical procedures, extraction of impacted third molars also has its complication: most common being pain, oedema, and trismus, which directly affect the patient's quality of life[1]. Other complications include dry socket, bleeding, delayed wound healing, injury to inferior alveolar nerve etc[1]. The biological effect of photobiomodulation occurs by absorption of the photons by the tissues and cellular structures; and this interaction results in the therapeutic effects[7].

The effect of photobiomodulation on reducing the post operative complications after third molar surgery have not been consistent.[1] The inconsistency may be due to the difference in surgical technique, different methods of measuring the complications and the different wavelengths used[1].

**Aim**

The aim of the study was to determine the advantages of using photobiomodulation therapy using 940nm diode laser after third molar surgery.

**Materials and Methods**

Patients reported to Department of Oral and Maxillofacial Surgery, KLE VK Institute of Dental Sciences with impacted mandibular third molars were included based on the inclusion criteria. The patients were randomly allocated to one of the two groups: the experiment or the control group. The patients in the experiment group

were given photobiomodulation pre-operatively, immediately post operatively and on the second post operative day both extra orally and intraorally.

**Results**

A total of 32 patients were selected in the study divided into two groups. The patients in the experiment group reported less pain. The mouth opening improved on the second post operative day as compared to the improvement on the seventh post operative day in the control group. The difference in swelling though clinically evident was not significant statistically.

**Conclusion**

In conclusion, photobiomodulation is a newer modality to reduce the post operative discomfort after third molar surgery.

**Keyword:** 'Photobiomodulation' 'Low-Level Laser therapy' ‘Impacted mandibular third molar’

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# INTRODUCTION

One of the most routinely performed procedures worldwide in the field of oral and maxillofacial surgery is the extraction of third molars- impacted or otherwise[1]. Multiple variables including the root morphology, tooth position and angulation, the thickness of the overlying bone, the amount of tooth structure lost, relation with the second molar predict the difficulty of the procedure[1]. As with all surgical procedures, extraction of impacted third molars also has its complication: most common being pain, oedema, and trismus, which directly affect the patient's quality of life[1]. Other complications include dry socket, bleeding, delayed wound healing, injury to inferior alveolar nerve etc[1]. Maximum pain is experienced by the patient three to five hours post-surgery, who endures it for two to three days and gradually diminishes till the seventh day. Swelling however starts appearing only after 12-48 hours resolves within five to seven days. Tonic contraction of masticatory muscles is called as trismus. Trismus is common due to various reasons after extraction of impacted third molars. Though these complications usually resolve by themselves, they do affect the quality of life and in turn patient satisfaction, which is of paramount importance to the surgeons. It is possible to manage these complications pharmacologically, but pharmacological management has its own side effects. Photobiomodulation is a much safer alternative to prevent these complictions[1]

"LASER" stands for "Light Amplification by the Stimulated Emission of Radiation". It was presented in 1959 by Gordon Gould a graduate student in the Columbia University. The first functioning laser was manufactured by Theodore Maiman, using helium and neon at the "Hughes Research Laboratories in Malibu, CA". Lasers were introduced in the field of dentistry by Miaman in 1961. Lasers

based on their application can be divided into hard lasers and soft lasers. Hard lasers can be used on both hard and soft tissues but soft lasers which can only be used on soft tissues. The soft lasers are also called as cold lasers which are made up of semiconductor diode, and are low cost and compact devices predominantly used for Low Level Laser Therapy or Biomodulation[2]. Diode lasers are most commonly used for periodontal therapy, bleaching and photobiomodulation[3]. Pecaro et al in 1983 first used lasers instead of scalpel for oral surgical procedures which resulted in bloodless surgical field[4]. Roynesdal et al in 1993 concluded that pain in the laser group 6 hours post operatively was lesser than in the placebo group[5].

Moist environment, presence of parakeratinised mucosa, polymicrobial niche with complex biofilms differentiate the healing of oral soft tissues from skin[6]. Healing after tooth extraction occurs by secondary intention and in four overlapping phases: haemorrhage; inflammation; proliferation and maturation phase[6]. The biological effect of photobiomodulation occurs when the photons are taken up by cells and tissues which results in the therapeutic effects[7].

The effect of photobiomodulation on alleviating the post operative sequalae after third molar surgery have not been consistent.[1] The inconsistency may be due to the difference in surgical technique, different methods of measuring the complications and the different wavelengths used[1].

# AIM AND OBJECTIVES

## AIM

The aim of this study was to determine the advantages of photobiomodulation therapy using 940 nm diode laser after third molar surgery.

## OBJECTIVES

To assess the effectiveness of photobiomodulation using 940 nm diode laser in reducing:

- Post-operative pain.
- Post-operative swelling.
- Post-operative trismus.

## NULL HYPOTHESIS

Photobiomodulation using 940 nm diode laser has no effect on pain, swelling and trismus after third molar surgery.

## ALTERNATIVE HYPOTHESIS

Photobiomodulation using 940 nm diode laser has significant effect on reducing pain, swelling and trismus after third molar surgery.

# REVIEW OF LITERATURE

In **1993**, **Roynesdal et al**[5] conducted a split-mouth study where the participants and the operator were blinded, in 25 subjects indicated for removal of bilaterally impacted lower third molars. A biophoton laser was used with 830 nm wavelength to irradiate patients pre and post operatively. The points of application of laser have not been mentioned. No consequential difference was found with reference to pain, oedema and trismus in this study. However, the study group demonstrated decreased pain scores than the non-LLLT group at the end of six hours.

**Fernando et al**[8] in **1993** did a double blinded randomized cross over trial in 52 patients. The side in the laser group was irradiated using 830 nm laser immediately post operatively. The point of application was directly in the socket. No marked difference in pain, swelling and healing was found amongst the two groups: the laser group and the control group.

A study by **Markovic et al**[9] in **2007** compared the efficacy of dexamethasone with photobiomodulation in a total of 120 subjects split into four groups:

Group 1- LPL radiation soon after extraction

Group2- LPL radiation+4mg dexamethasone IM in medial pterygoid muscle

Group 3- LPL radiation+4mg dexamethasone systemically IM deltoid region+4mg dexamethasone intraorally at 6h

Group 4- routine management (control)

This study concluded that giving LPL along with intramuscular injection of 4mg dexamethasone into the medial pterygoid was the most effective in reducing the

post operative oedema. Group 1 and group 3 did not report any noteworthy difference, but oedema in group 4 was the greatest.

**Amirallas-Escobar**[10] in **2010** lead a double blinded randomized control trial to assess the use of Low-Level Laser Therapy after surgical extraction of mandibular third molars in a sample size of 30 subjects, randomly allocated to control and experimental groups. This study was unique in laser application protocol as patients in experimental group were irradiated immediately post-operatively using 810 nm laser intraorally 1 cm from the affected area. However, in the post operative period laser was applied extra orally at 24, 48 and 72 hours at a total of 6 points: three points 3 cm apart on the imaginary line joining the tragus to the corner of mouth three points 3 cm apart on the imaginary line joining the ear lobe to soft tissue pogonion.

Although, difference in pain in the two groups was not statistically significant, the time after which rescue analgesics were taken was statistically significant. The differences in swelling and trismus though clinically visible, were not statistically significant. This might be because all patients were given a dose of dexamethasone 4 mg intramuscularly post operatively.

**Aras et al**[11] in **2010** performed a study to compare intra oral and extra oral LLLT in reducing post operative trismus and swelling on 48 subjects having mesioangular impacted lower 3$^{rd}$ molars. They were segregated into the following groups: intraoral, extraoral or placebo group. Intra oral group was given irradiation immediately post operatively at a point 1 cm away from target site. The extra oral group received irradiation at the insertion of masseter muscle at 808 nm continuous waveform. Their results concluded that trismus was lesser than the placebo group on

second and seventh after the procedure for the extraoral group in contrast to the intraoral group in which trismus was lesser than the placebo group only on the seventh day. The extraoral group reported lesser swelling two days after the surgical extraction.

A split-mouth, double blinded randomized control trial was led by **Lopez et al**[12] in **2012** to study the effectiveness of photobiomodulation for managing post operative pain, swelling and trismus in 20 subjects. They used 810 nm continuous waveforms immediately post operatively, intra orally at 1 cm distance; and with a spot of 0.7 cm moved in a circular manner to irradiate area of 2 cm diameter. No remarkable difference in pain was found amongst the two groups in the first 72 hours. Not much difference was found in swelling and trismus in both the groups. The experimental group had improved mouth opening in the first 48 hours, but variation was not considerable statistically.

**Ferrante et al**[13] in **2013** conducted a randomized control trial on 30 subjects with Class IIIB impacted molars. The subjects were randomly allocated to either to the experiment group or the control group. Subjects in the experimental group were given LLLT immediately post operatively and after 24 hours using 980 nm diode laser intra orally at the facial and lingual points 1cm away and extra orally at the insertion of masseter muscle. Pain measured using VAS scale, swelling by calculating the distance between commissure of mouth and the lower part of the earlobe. Trismus was measured using the interincisal distance. Trismus was lesser in the experimental group on day 2 and day 7. On post operative day one swelling was notably lesser in the experimental group. Lower pain scores were expressed by the photobiomodulation group but the difference was trivial.

A study done by **Abdel-Alim**[14] in **2015** demonstrated that photobiomodulation given immediately postoperatively resulted in less pain, trismus, and facial swelling rather than photobiomodulation given in the post operative period. A sample size of 80 was randomly distributed into immediate and delayed group. The patients in the former group received photobiomodulation shortly after procedure after which photobiomodulation was given on the third day after surgery whereas for the latter group patients were given photobiomodulation on the second and fourth day after the surgical procedure using 830 nm diode laser at a single extraoral point of insertion of masseter muscle.

**Fabre et al**[15] in **2015** reported a case series of ten patients, who were irradiated with 660nm diode laser 24 hours post operatively and then daily for three consecutive days. Oedema and trismus which appeared on the first day post-operatively gradually came back to normal after the first session of photobiomodulation.

**Kazancioglu**[16] in **2015** compared photobiomodulation to Ozone therapy for lowering the post-operative complications of the impacted last molar surgery. He led a double blinded randomized controlled trial of 60 participants randomly allocated to either of the three groups:

LLLT group was given to the first group

Ozone therapy was given to the second group

The third group served as the control group

The inference obtained from this study demonstrated better mouth opening on post operative days one and three in the LLLT group as compared to the two other

groups. However, on the seventh day the mouth opening was the same in all three groups. The LLLT group showed lesser oedema and pain in comparison to other groups. But the OHIP scores were better in the ozonated group.

**Merigo et al**[17] in **2015** led a double blinded randomized control trial on 59 patients indicated impaction of lower third molars. The study was divided in two parts: The first part was for the evaluation of swelling.

They had divided the participants in three groups:

One group of seventeen patients received LLLT along with traditional drug therapy.

The next group served as the control group of seventeen patients who only received traditional drug therapy

The second part of study had 25 participants who were given photobiomodulation only on one side to evaluate pain. Photobiomodulation was given immediately after surgery and 12 hours after the surgery. They used 910 nm at pulsed and super pulsed mode with 650nm continuous waveform both extra and intra orally.

They found that pain at 12 hours was greatest in the control group. Also, swelling was consequentially more in the control group.

**Eroglu et al**[18] in **2016** studied the effect of single session photobiomodulation with 940 nm diode laser on the pain, oedema and mouth opening after extraction of lower last molars which were impacted. This was a split mouth randomized study done on 35 subjects having bilateral Class IIB impacted molars. Laser was given immediately postoperative at the gonion, earlobe and mesial to the second molar extra

orally using 940nm continuous waveform laser. No remarkable difference was found in the pain, swelling and trismus post-operatively which was measured using VAS, distance between chin tip to the ear lobe and interincisal opening respectively.

In **2016 Eshghpour et al**[19] conducted a double blinded, split mouth prospective study to determine the effectiveness of LLLT in lowering post-operative pain and oedema after extraction of the lower last molars. Study was done on 44 subjects with Class I impaction bilaterally. Pain was evaluated using VAS and swelling by calculating the length between tragus and angle of mouth; and gonion and outer corner of eye. Statistical analysis favoured the group which received LLLT as pain and swelling was remarkably lesser than in the other group.

**Landucci et al**[20] in **2016** studied the "Efficacy of a single dose of low-level laser therapy in reducing pain, swelling, and trismus following third molar extraction surgery" in a split-mouth study of twenty-two subjects. One side was randomly allocated to the laser or study group and the other side to the other group. Irradiation was given at a total of ten point- 4 intraoral and six extraoral. Intra oral points included buccal, lingual, distal and middle of bony socket. Extra oral points included 2 points each at the insertion, middle part and origin of masseter muscle using 780 nm diode laser. Pain, oedema, and mouth opening was markedly better in the laser group immediately post-operatively and at 48 hours.

An article by **Pedreira et al**[21] in **2016** evaluated the clinical and thermographic outcomes of 808nm laser after surgical extraction of lower wisdom tooth. The difference between the aforementioned study and other studies was that it also included the maxillary third molars, and it also evaluated the temperature change or change in micro circulatory pattern after extraction using an infrared camera. This

study had four groups: the first group consisted of patients with extraction of erupted third molars, not irradiated. The second group included patients with extraction of erupted third molars, irradiated. The third group consisted of patients diagnosed with impaction of mandibular third molars, not irradiated. The fourth group constituted patients diagnosed with impaction of third molars and irradiation was given. Total lack of pain was reported on day 7 by patients in Group II. Degree of pain was higher in Group III than Group IV but not statistically significant. No significant changes in trismus and oedema were noted in all the four groups. There was a decrease in temperature in angle region in Group III than Group IV which was statistically significant.

In **2016 Sierra et al**[22] led a study to help choose between intra oral or extraoral and infrared or red-light laser application. They had divided 60 subjects in five groups: intra oral application 660nm laser was the first group, intraoral application of 808 nm laser comprised of the second group, the group received extraoral application with 660 nm laser, extra oral application of 808nm was given to the subjects in fourth group and the fifth group was the control group. In this study no noteworthy variation was observed in the swelling and mouth opening amongst the groups. Nevertheless, they inferred that depth of penetration for red light was shorter as compared to infrared light. Accordingly, red light should be used intra orally whereas it more beneficial to use infrared light extra orally.

A randomized study by **Koparal et al**[23] in **2016** studied the "effects of low-level laser therapy following surgical extraction of the lower third molar with objective measurement of swelling using a three-dimensional system." The third molar difficulty level included in the study was Class III B "Pell and Gregory

classification". A sample size of 45 was divided into 3 groups: Routine management of ice application was prescribed for Group 1; Single-dose of LLLT was given immediately post-operatively for Group 2 and the third group was given two doses of photobiomodulation shortly after extraction and on second day after the procedure. Compass was used to measure the interincisal opening to evaluate trismus; pain was evaluated using VAS and oedema was evaluated using 3dMD by Atlanta. A GaAlAs laser was used with 810 nm continuous waveform at only one extra oral point of insertion of the masseter. This study did not find any contrasting variation in swelling and trismus in all the three groups; however, pain was the least in the third group.

In **2017**, **Raiesian et al**[24] published a prospective RCT in which both operator and patients were blinded trial assessing the effects of photobiomodulation following extraction of lower third molars. This study included 44 patients. Fifteen participants participated in the split-mouth study design to evaluate pain and swelling. The remaining patients were allocated either to the laser or the placebo group to evaluate the trismus. All patients with Grade IIIB according to Winter Gregory classification were included in the study. A diode, fixed contact mode laser was used in 980 nm continuous waveform; immediately and 24 hours after surgery at emergence of masseter muscle extra orally and intraorally 1 cm away from the surgical site buccally and lingually. No remarkable difference was noted in oedema and trismus in both the groups. However, pain was notably lower in the experiment group at 24 hours and 7 days than the control group.

A retrospective study of 45 subjects was done by **Petrini et al**[25] in **2017**, which included Class IIIB and Class IIIC lower third molars to study "The effect of

pre-operatory low-level laser therapy on pain, swelling, and trismus associated with third-molar surgery". Controls were managed routinely with ice application. Patients given LLLT immediately post-operatively and at 24 hours along with routine management comprised of Group 1. Group 2 constituted of patients given LLLT immediately pre-operatively and post-operatively along with routine management of ice application. Pain, swelling, and trismus was evaluated using VAS, distance between auricular lobe and tip of chin and interincisal distance respectively. A 980 nm continuous waveform diode laser was used extra orally at the skin over masseter and intra orally at lingual and buccal side of alveolus in circular motion. Pain scores were similar in all the three groups. Pre operative group accounted for considerably lesser consumption of analgesics as compared to the other two groups. Even though the oedema was lower subjects receiving LLLT as compared to the subjects who did not receive LLLT the difference was not remarkable analytically. The interincisal opening in group 2 at the end of 7 days was remarkably better than the other two groups.

In **2017**, **Kahraman et al**[26] published a randomized split mouth placebo controlled, single-blinded trial conducted across two centres to "study on the effects of transcutaneous and intraoral low-level laser therapy after extraction of lower third molars". In this trial a sample size of 60 was divided into the following three groups:

Group A: transcutaneous photobiomodulation group

Group B: intraoral photobiomodulation group and

Group C: placebo group.

Only pain was evaluated using VAS in this study. Laser was applied immediately before and after extraction on the region of masseter muscle in Group A

and in the third molar region in Group B using a diode laser at 830 nm in continuous waveform. Subjects in intraoral pain group reported lesser pain scores than in the transcutaneous group.

**Hamid et al**[27] in **2017** studied the "effects of Low-level Laser Therapy on Postoperative Pain after Mandibular Third Molar Surgery". This was a prospective, double-blinded, split-mouth prospective study done on 30 patients diagnosed with impacted lower third molars with Pederson difficulty index ranging from 3 to 8. A GaAlAs diode laser with 810 nm continuous waveform was used on the laser side at the following points: buccal, lingual and occlusal shortly after the procedure. The pain scores and the consumption of analgesics after administration of photobiomodulation was markedly lesser.

**Farhadi**[28] in **2017** evaluated "the role of adjunctive effect of low-level laser Therapy on pain, swelling and trismus after surgical removal of impacted lower third molar" in a double-blinded RCT consisting of 24 sampled randomly allocated to control and experimental groups. Participants belonging to the latter group were given laser, immediately post operatively using 550 nm continuous waveform intraorally at the extraction site and extra orally at site of insertion of masseter muscle. This study concluded that LLLT did not have any consequential effect on reducing the post operative sequalae.

A split mouth randomized control trial by **Alan et al**[23] in **2017**, evaluated "the effects of the low-level laser therapy on swelling, pain, and trismus after removal of impacted lower third molar". This trial included 15 patients with bilaterally impacted Grade IIIB impactions. Subjects in the study group were given 810nm of continuous waveform laser therapy immediately post-operatively and on day 2 at the point of

insertion of masseter muscle. Pain score, oedema and trismus in the two groups had similar values except, that on 7th day after the procedure pain was remarkably lesser in the laser group.

A prospective, single-center, double-blinded randomized pilot study by **Asutay et al**[29] was published in August **2018**, concluded that LLLT had no significant result on oedema and trismus. However, statistically significant effect was seen in VAS scores on the 7th postoperative day. This study had 3 groups:

Group 1 control group who were routinely managed with ice application

Group 2 which received extraoral application of Low-Level Laser Therapy after surgery.

Group 3 was the sham group who were given sham LLLT.
A total of 45 subjects were randomly assigned to one of the groups. All surgical extractions were done by the same operator, using 40 mg/mL of articaine as the choice of local anaesthetic agent. Following which a full thickness three cornered flap was raised, followed by bone guttering and tooth sectioning as required. All patients were prescribed combination of amox-clavulonic acid, paracetamol and chlorhexidine mouthwash post-operatively. An "GaAlAs diode laser" by "CHEESE Dental Laser System, Wuhan Gigaa Optronics Technology Company, China" was used in continuous waveform of 810nm was given at a single extraoral point: the insertion of the masseter muscle[30].

**Ali Peimani et al**[1] conducted a double-blinded randomized controlled study in **2018** on 30 subjects, divided into two groups: Control group and Case group. Pain was evaluated using VAS, swelling was determined by measuring the distance

between canthus of eye and gonion; tragus and corner of mouth and tragus of ear to pogonion; interincisal distance was used to determine the mouth opening and patients were asked to fill OHIP-14 questionnaire. This study found no statistically remarkable difference in pain, oedema, mouth-opening and OHIP-14 questionnaire scores.

# MATERIALS AND METHODS

**STUDY DESIGN:**

Prospective, Single Blinded, Randomized Control Trial.

**SOURCE OF DATA:**

The study was conducted in the Department of Oral and Maxillofacial Surgery, "K.L.E. Vishwanath Katti Institute of Dental Sciences", K.A.H.E.R, Belagavi, Karnataka with due permission of the institutional ethical committee. The procedure was described to all patients and a written informed consent was signed by them.

**INCLUSION CRITERIA:**

- Age of patient should be ranging from 18-50 years.
- Patients requiring surgery for of lower last molars for either prophylactic or therapeutic reasons and are willing for the same.
- Patients with moderate surgical difficulty score on Pederson's index (4-6).
- Patients with ASA status I and normal coagulation profile.

**EXCLUSION CRITERIA**:

- Medically compromised patients.
- Patients with chronic pain, neurological or psychiatric disorder.
- Patients with severe periodontal disease.
- Patients unwilling to be a part of this study.

- Patients who have known allergies to the drugs or anaesthetics to be used during the procedures.
- Patients who are pregnant or lactating.
- Patients on analgesics in the preceding 2 weeks.
- Chronic smokers.
- Patients with history of consumption of bisphosphonates.
- Patients with family history of photosensitivity.

**LABORATORY DETAILS**:

- Haemoglobin
- Bleeding time
- Clotting time
- Random Blood Sugar
- Orthopantomogram/ Intraoral Periapical radiograph

**SURGICAL ARMAMENTARIUM:**

- Surgical gloves
- Mouth mirror
- Dental explorer
- Tweezer
- 2ml Disposable Syringe
- Surgical scalpel blade no. 15
- Periosteal elevator
- Straight elevator
- Artery forceps

- Curette
- Bone file
- Needle holder
- Adson's tissue forceps
- Scissors
- Surgical handpiece and bur
- Kidney tray
- Irrigation syringe 20ml
- Surgical drape
- Towel clip
- Suction tip
- Langenbeck retractor
- Sponge holder
- Gauze piece
- BioLase Epic Laser
- Laser Handpiece
- Wireless Foot Control
- Protective eyewear

**METHODOLOGY:**

Computer generated random allocation of 32 patients with mandibular impacted third molar diagnosed by established clinical and radiographic parameters and who met the inclusion criteria was done into two groups of 16 each:

Group A: study group.

Group B: control group.

Preoperatively patients were asked to fill the VAS score. Extra oral measurements between the following points were noted:

- Tragus to pogonion
- Tragus to angle of mouth
- Outer canthus of eye to gonion

The inter incisal space was measured to determine the mouth opening.

**Group A: Study group:** Patients received Photobiomodulation therapy (PMBT) pre-operatively at 9J/cm $^2$ at 0.1W for 90 seconds at the following points:

- Extraoral
    - The angle of mandible
    - Point 1cm superior to the angle of mandible
    - Point 1cm anterior to the angle of mandible
    - Point 2cm anterior to the angle of mandible
- Intraoral
    - Point on the buccal aspect of 1$^{st}$ molar
    - Point on the buccal aspect 1cm distal to the first molar.
    - On the buccal aspect 2cm distal to the first molar.
    - On the lingual aspect of the extraction socket.

The removal of lower last molars was done surgically.

Patients received photobiomodulation immediately post-operatively at the same points.

Same antibiotics and analgesics were given.

Patients were recalled on the 2nd day. Patients were asked to fill the VAS score. Extra oral measurements between the following points were noted:

- Tragus to pogonion
- Tragus to angle of mouth
- Outer canthus of eye to gonion

The inter incisal space was measured to determine the mouth opening.

PMBT was given at the same points.

Patient recalled on the 7th day. Patients were asked to fill the VAS score. Extra oral measurements between the following points were noted:

- Tragus to pogonion
- Tragus to angle of mouth
- Outer canthus of eye to gonion

The inter incisal space was measured to determine the mouth opening.

**Group B: Control group:** Patients did not receive PMBT.

The removal of lower last molars was done surgically.

Patients did not receive PMBT.

Same antibiotics and analgesics will be given

Patients were recalled on the 2nd day. Patients were asked to fill the VAS score. Extra oral measurements between the following points were noted:

- Tragus to pogonion
- Tragus to angle of mouth
- Outer canthus of eye to gonion

The inter incisal space was measured to determine the mouth opening.

No PMBT was given.

Patients recalled on the 7th day. Patients were asked to fill the VAS score. Extra oral measurements between the following points were noted:

- Tragus to pogonion
- Tragus to angle of mouth
- Outer canthus of eye to gonion

The inter incisal space was measured to determine the mouth opening.

Patients in both the groups were prescribed the following medication:

CAP. AMOXICILLIN 500mg 1-1-1 X 5days

TAB. DOLONEX DT 1-0-1 X 5days

TAB. PAN 40 mg 1-0-0 X 5 days

None of the patients were allergic to the prescribed medication.

**Follow up:**

On the 2nd and 7th day after surgical extraction of third molar.

**STUDY VARIABLES:**

The primary outcome variables were:

Pain- VAS scale

Oedema- Distance between the following points:

- Tragus to the Pogonion (Tip of chin)
- Tragus to angle of mouth
- Lateral canthus of eye to gonion

Trismus- mouth opening measured by the interincisal distance

**DATA COLLECTION METHODS AND ANALYSIS:**

Data collection was done pre operatively, on the second post operative day and on the seventh preoperative day.


**Figure 1: Laser Equipment (BioLase)**

**Figure 2: Surgical Equipment (BioLase)**

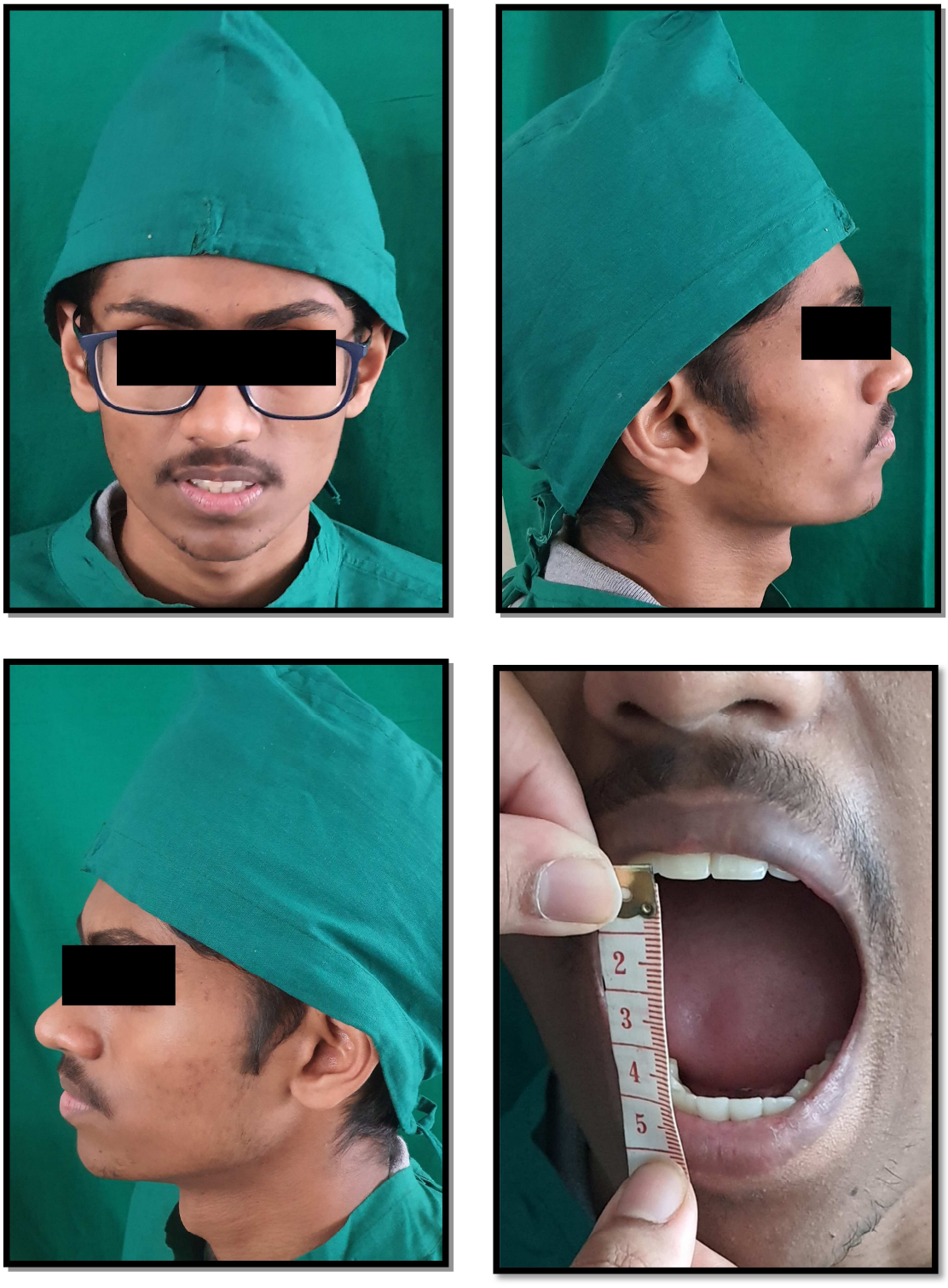



**Figure 3: Pre operative**


**Figure 4: Postoperative Day 2**


**Figure 5: Postoperative Day 7**


**Figure 6: Preoperative**


**Figure 7: Postoperative Day 2**


**Figure 8: Post operative Day 7**

**Figure 9: Extraoral Points Irradiated**

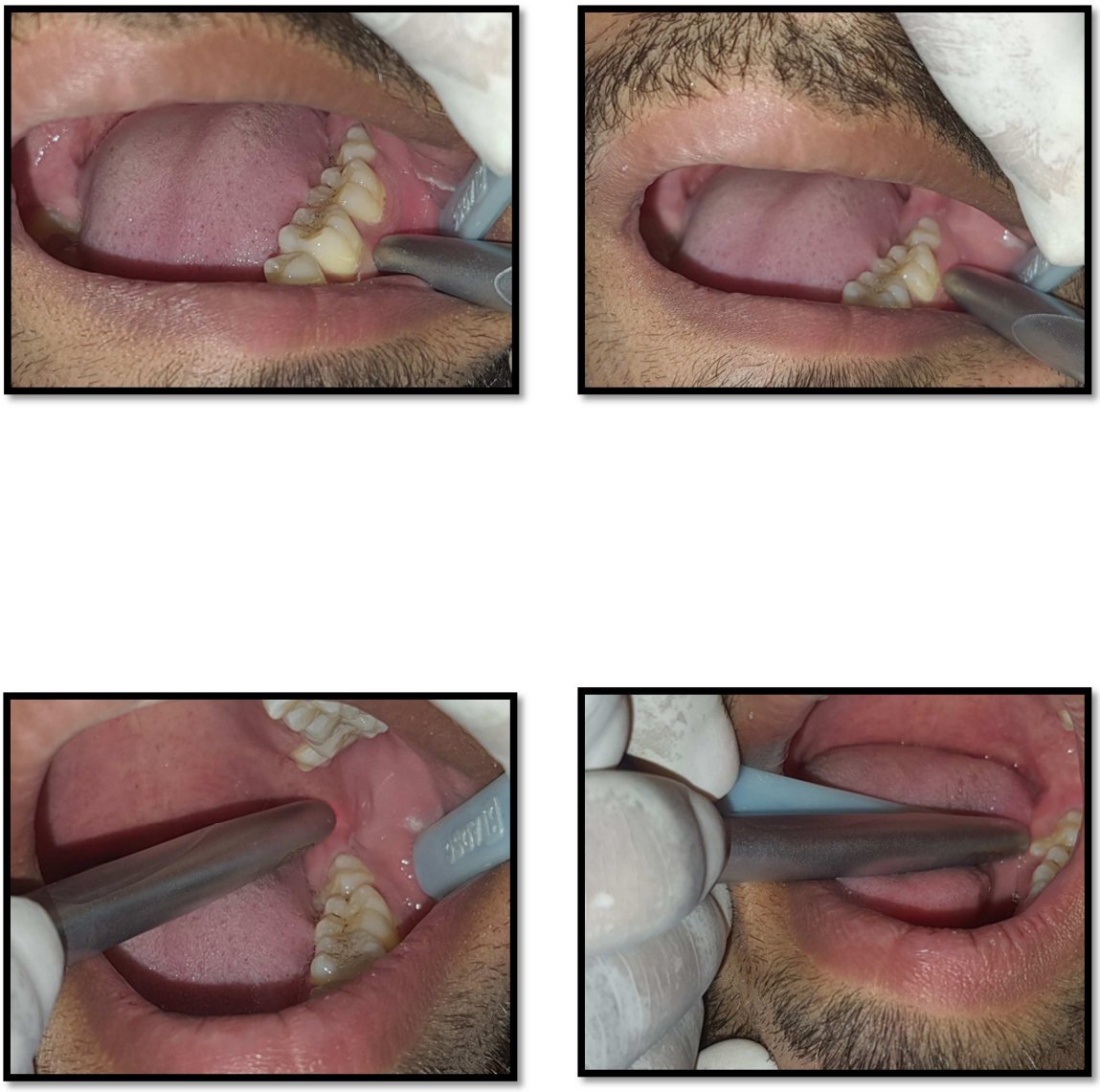


**Figure 10: Intraoral points irradiated**

# RESULTS

## DEMOGRAPHIC DATA

In this single blinded, randomized control trial a total of 32 subjects (17 males and 15 females) were included. Eight males and eight females (n=8) were present in the study group. Nine males and seven females constituted the control group.

Majority of the patients that is 10 patients in the experiment group were between 20 to 29 years old. The remaining six patients were between 30 to 39 years in the experiment group. Control group had six patients from 20 to 29 years, seven patients from 30-39 years and 3 patients were above 40 years.

Nine out of sixteen patients in the experiment group had their left mandibular third molar extracted. In the experiment group seven patients had their right mandibular third molar extracted. In the control group eleven patients had their left lower third molar extracted and five had their right lower third molar extracted.

The below table compares the demographic profile of patients included in both the groups.

**Table 1: Demographic profile of participants in experiment group and control group**

| Profile | Experiment group | % | Control group | % | Total | % | | P-value |
|---|---|---|---|---|---|---|---|---|
| **Gender** | | | | | | | | |
| Male | 8 | 50.00 | 9 | 56.25 | 17 | 53.13 | $\chi^2$=0.125 | 0.7230 |
| Female | 8 | 50.00 | 7 | 43.75 | 15 | 46.88 | | |
| **Age groups** | | | | | | | | |
| 20-29yrs | 10 | 62.50 | 6 | 37.50 | 16 | 50.00 | $\chi^2$=4.077 | 0.1300 |
| 30-39yrs | 6 | 37.50 | 7 | 43.75 | 13 | 40.63 | | |
| >=40yrs | 0 | 0.00 | 3 | 18.75 | 3 | 9.38 | | |
| Mean age | 27.06 | | 30.50 | | 28.78 | | t=-1.216 | 0.2335 |
| SD age | 6.31 | | 7.47 | | 7.02 | | | |
| **Tooth involved** | | | | | | | | |
| 38 | 9 | 56.25 | 11 | 68.75 | 20 | 62.50 | $\chi^2$=0.533 | 0.4650 |
| 48 | 7 | 43.75 | 5 | 31.25 | 12 | 37.50 | | |
| Total | 16 | 100.0 | 16 | 100.00 | 32 | 100.00 | | |

**PAIN**

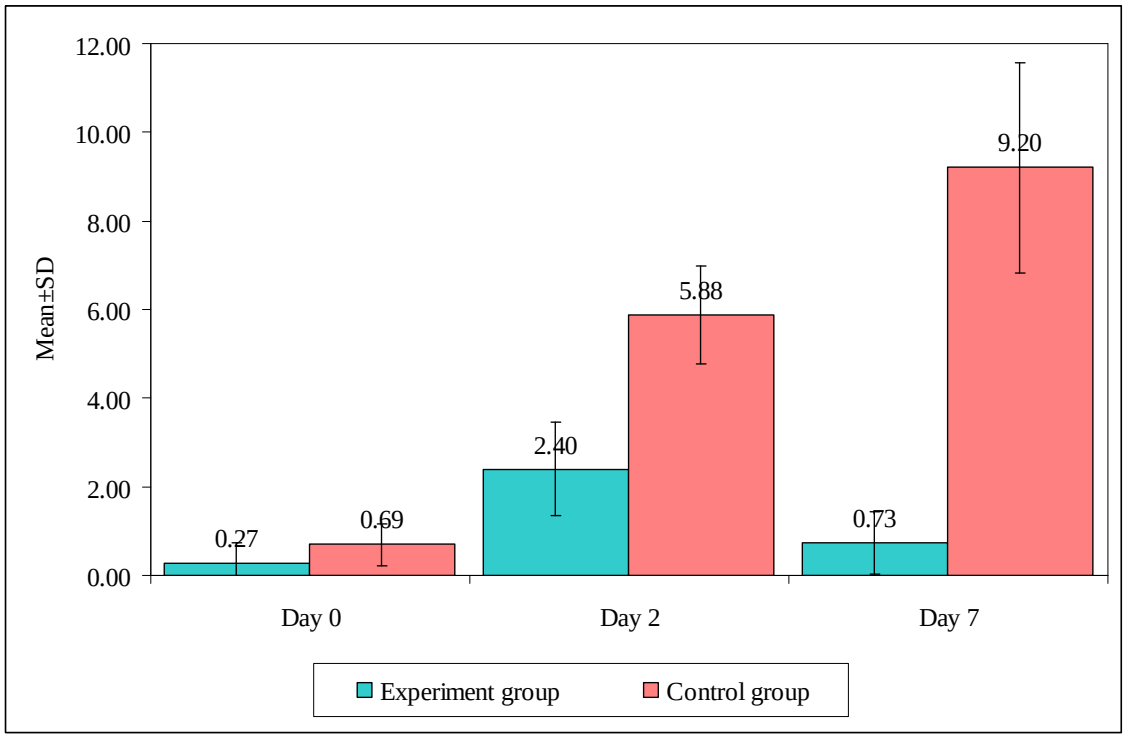
Pain score between both the groups were compared using VAS scores at various time frames: preoperatively, at day 2 and on day 7 using Mann-Whitney U test. A statistically remarkable difference in pain was found on the second and the seventh day after the procedure. The pain scores of subjects in study group were markedly reduced in comparison to the group not given laser therapy with a statistical difference. The pain from day 0 to day 2 increased in both the groups but the increase in pain was more in participants not receiving the intervention and difference was considerable analytically.

**Table 2: Comparison of pain scores in experiment group and control group at different treatment time points by Mann-Whitney U test**

| Treatment times | Experiment group | | | Control group | | | U-value | Z-value | p-value |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean rank | Mean | SD | Mean rank | | | |
| Day 0 | 0.27 | 0.46 | 12.63 | 0.69 | 0.48 | 19.16 | 69.50 | -1.9462 | 0.0580 |
| Day 2 | 2.40 | 1.06 | 8.13 | 5.88 | 1.09 | 23.38 | 2.00 | -4.6644 | 0.0001* |
| Day 7 | 0.73 | 0.70 | 9.20 | 2.38 | 0.81 | 22.38 | 18.00 | -4.0319 | 0.0001* |
| Day 0 to Day 2 | 2.13 | 0.99 | 8.47 | 5.19 | 1.33 | 23.06 | 7.00 | -4.4667 | 0.0001* |
| Day 0 to Day 7 | 0.47 | 0.64 | 10.47 | 1.69 | 0.95 | 21.19 | 37.00 | -3.2809 | 0.0010* |
| Day 2 to Day 7 | -1.67 | 0.90 | 22.30 | -3.50 | 1.15 | 10.09 | 25.50 | -3.7354 | 0.0002* |

*$p<0.05$

**Figure 1: Comparison of experiment group and control group with pain scores at different treatment time points**




The above graph demonstrates the pain across various time frames at day 0, day 2, and day 7. It can be seen that though there is an increase in pain on day 2 in both the groups, the increase is more in the group which received no photobiomodulation. The pain on day 7 increased in the control group whereas in the experiment group the pain reduced.

**SWELLING**

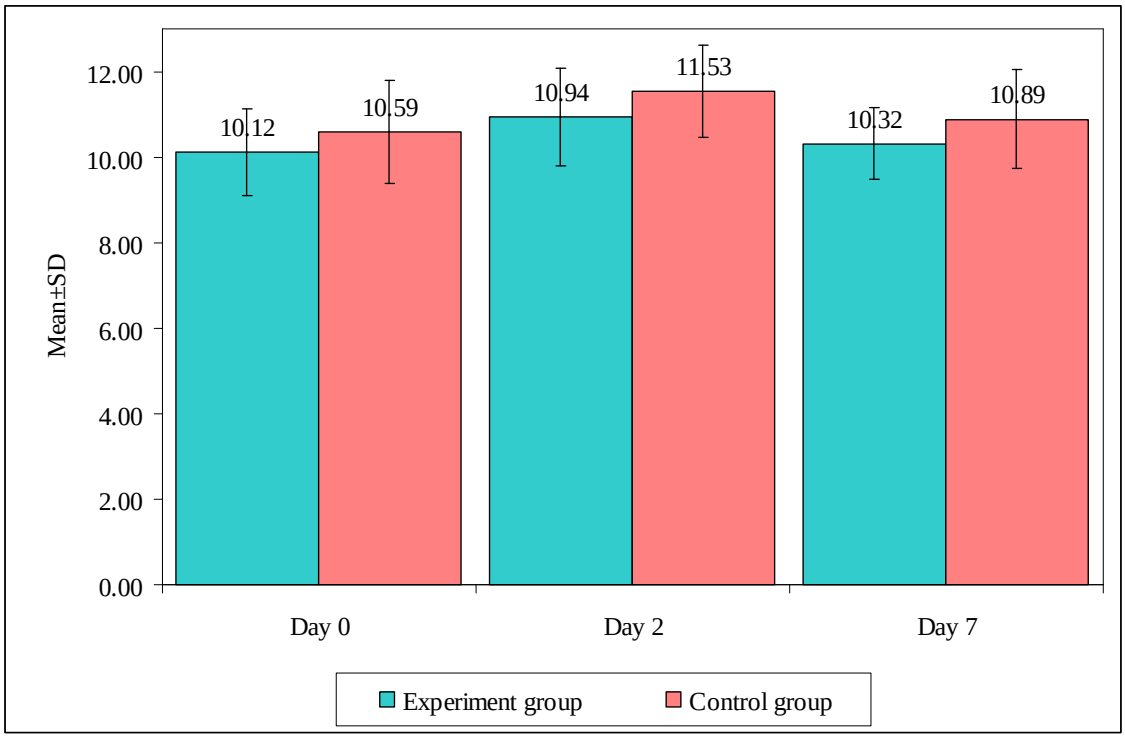
**LATERAL CANTHUS OF EYE TO ANGLE OF MANDIBLE**

The values of swelling measured from outer corner of eye to gonion were compared using independent t test. However, no significant statistical difference was found on the second and seventh post-operative day.

**Table 3: Comparison of swelling LCoE-AoM scores in experiment group and control group at different treatment time points by independent t test**

| Treatment times | Experiment group | | Control group | | t-value | p-value |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| Day 0 | 10.12 | 1.01 | 10.59 | 1.21 | -1.1757 | 0.2493 |
| Day 2 | 10.94 | 1.13 | 11.53 | 1.08 | -1.4867 | 0.1479 |
| Day 7 | 10.32 | 0.85 | 10.89 | 1.16 | -1.5458 | 0.1330 |
| Day 0 to Day 2 | 0.82 | 0.35 | 0.94 | 0.27 | -1.0372 | 0.3082 |
| Day 0 to Day 7 | 0.20 | 0.28 | 0.29 | 0.12 | -1.2183 | 0.2329 |
| Day 2 to Day 7 | -0.62 | 0.42 | -0.64 | 0.22 | 0.2001 | 0.8428 |

**Figure 2: Comparison of swelling in experiment group and control group at different treatment time points using LCoE-AoM scores**




The above graph shows that the mean values on day 0, day 2 and day 7 across both the groups are similar. The experiment group has slightly lesser values but the difference is not statistically significant.

The table below compares the swelling in both the groups at various times: preoperatively, second day after surgery and seventh day after surgery. It can be summarized as:

The swelling in both the groups increases significantly from day 0 to day 2

The swelling decreases from day2 to day7 in both the groups but the decrease is more in the experiment group.

**Table 4: Comparison of swelling- LCoE-AoM scores at different treatment time points within experiment group and control group by dependent t test**

| Groups | Time points | Mean | SD | Mean Diff. | SD Diff. | % of change | t-value | p-value |
|---|---|---|---|---|---|---|---|---|
| Experiment group | Day 0 | 10.07 | 1.00 | | | | | |
| | Day 2 | 10.88 | 1.12 | -0.81 | 0.34 | -8.07 | -9.4411 | 0.0001* |
| | Day 0 | 10.07 | 1.00 | | | | | |
| | Day 7 | 10.27 | 0.85 | -0.20 | 0.27 | -1.99 | -2.9542 | 0.0098* |
| | Day 2 | 10.88 | 1.12 | | | | | |
| | Day 7 | 10.27 | 0.85 | 0.61 | 0.40 | 5.63 | 6.0529 | 0.0001* |
| Control group | Day 0 | 10.59 | 1.21 | | | | | |
| | Day 2 | 11.53 | 1.08 | -0.94 | 0.27 | -8.85 | -13.7389 | 0.0001* |
| | Day 0 | 10.59 | 1.21 | | | | | |
| | Day 7 | 10.89 | 1.16 | -0.29 | 0.12 | -2.77 | -9.5019 | 0.0001* |
| | Day 2 | 11.53 | 1.08 | | | | | |
| | Day 7 | 10.89 | 1.16 | 0.64 | 0.22 | 5.58 | 11.7583 | 0.0001* |

*$p<0.05$

**TRAGUS OF EAR TO CORNER OF MOUTH**

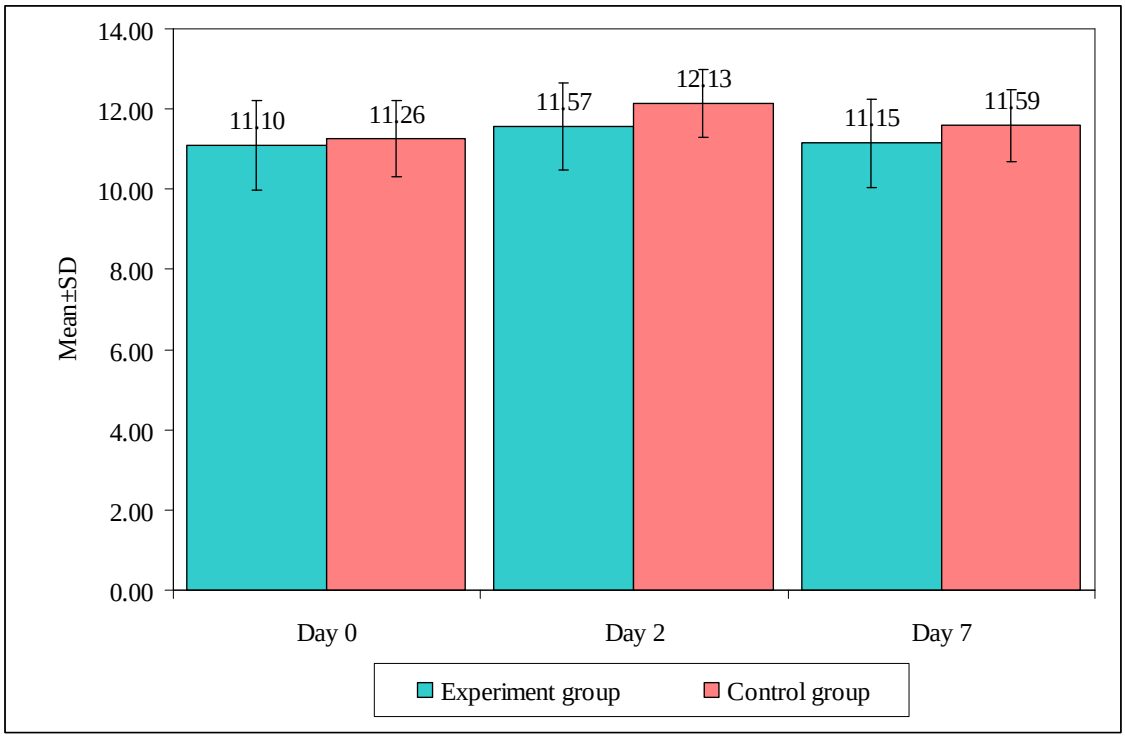
The table shows no significant difference in swelling was calculated from tragus of ear to oral commissure in both the groups. The increase in oedema from day0 to day2 was more in the control group and statistically significant. The oedema from day0 to day 7 also increased in both the groups but was consequentially lesser in the experiment group.

**Table 5: Comparison of swelling using T-CoM scores in experiment group and control group at different treatment time points by independent t test**

| Treatment times | Experiment group | | Control group | | t-value | p-value |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| Day 0 | 11.10 | 1.12 | 11.26 | 0.95 | -0.4372 | 0.6652 |
| Day 2 | 11.57 | 1.07 | 12.13 | 0.85 | -1.6189 | 0.1163 |
| Day 7 | 11.15 | 1.09 | 11.59 | 0.89 | -1.2331 | 0.2274 |
| Day 0 to Day 2 | 0.47 | 0.34 | 0.87 | 0.34 | -3.2115 | 0.0032* |
| Day 0 to Day 7 | 0.05 | 0.08 | 0.33 | 0.13 | -6.8811 | 0.0001* |
| Day 2 to Day 7 | -0.43 | 0.31 | -0.54 | 0.31 | 1.0620 | 0.2970 |

*$p<0.05$

**Figure 3: Comparison of swelling using T-CoM scores in experiment group and control group at different treatment time points**




The figure above demonstrates that the swelling on day2 and day7 in control group was much more than the experiment group.

The table below shows the percentage of change across various time durations. The percentage of change from day0 to day2 in both the groups shows increase in swelling but the change is more in the control group signifying markedly more swelling on the second post-operative day than in the experiment group A. The swelling decreased from day 2 to day 7 in both the groups but the percentage of change was more in the control group which is may be contributed to the fact that the swelling in the non-LLLT group was more on the second post-operative day as compared to the experiment group.

**Table 6: Comparison of swelling using T-CoM scores at different treatment time points in experiment group and control group by dependent t test**

| Groups | Time points | Mean | SD | Mean Diff. | SD Diff. | % of change | t-value | p-value |
|---|---|---|---|---|---|---|---|---|
| Experiment group | Day 0 | 11.04 | 1.11 | | | | | |
| | Day 2 | 11.54 | 1.04 | -0.49 | 0.34 | -4.47 | -5.8166 | 0.0001* |
| | Day 0 | 11.04 | 1.11 | | | | | |
| | Day 7 | 11.11 | 1.07 | -0.06 | 0.10 | -0.57 | -2.4398 | 0.0276* |
| | Day 2 | 11.54 | 1.04 | | | | | |
| | Day 7 | 11.11 | 1.07 | 0.43 | 0.30 | 3.74 | 5.7836 | 0.0001* |
| Control group | Day 0 | 11.26 | 0.95 | | | | | |
| | Day 2 | 12.13 | 0.85 | -0.87 | 0.34 | -7.71 | -10.1036 | 0.0001* |
| | Day 0 | 11.26 | 0.95 | | | | | |
| | Day 7 | 11.59 | 0.89 | -0.33 | 0.13 | -2.89 | -9.6896 | 0.0001* |
| | Day 2 | 12.13 | 0.85 | | | | | |
| | Day 7 | 11.59 | 0.89 | 0.54 | 0.31 | 4.48 | 7.1209 | 0.0001* |

*$p<0.05$

**TRAGUS TO POGONION**

**Table 7: Comparison of swelling using T-Pog scores in experiment group and control group at different treatment time points by independent t test**

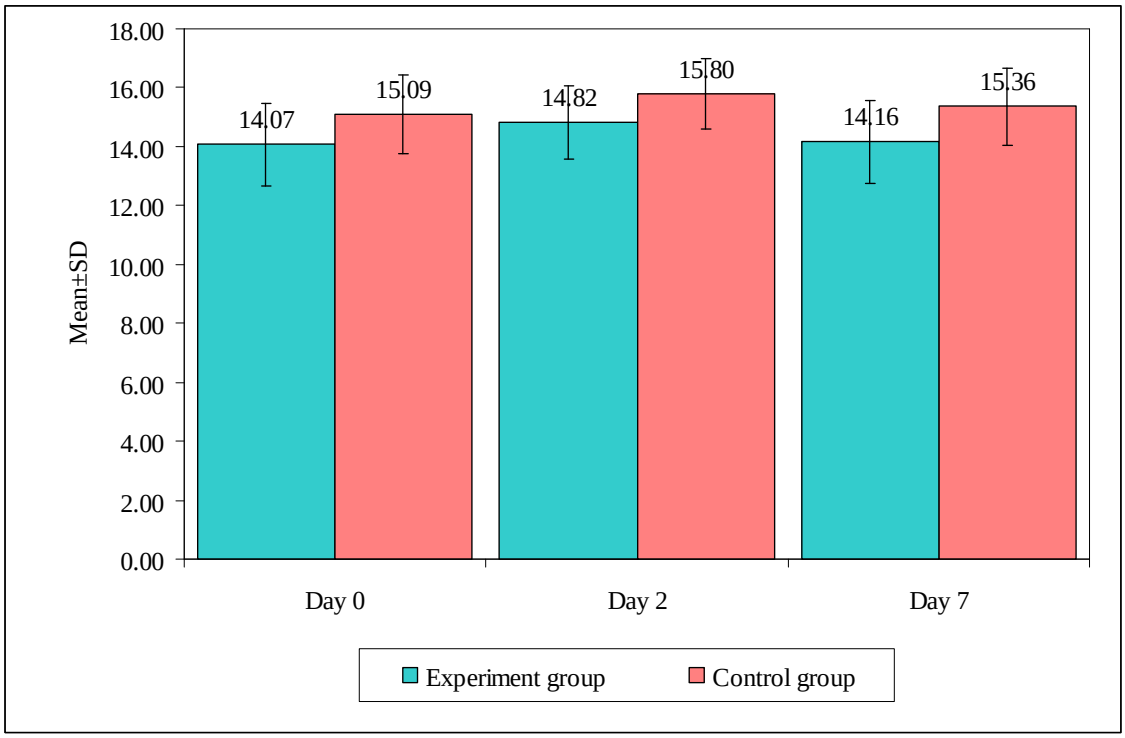
| Treatment times | Experiment group | | Control group | | t-value | p-value |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| Day 0 | 14.07 | 1.39 | 15.09 | 1.34 | -2.0670 | 0.0478 |
| Day 2 | 14.82 | 1.26 | 15.80 | 1.19 | -2.2345 | 0.0333* |
| Day 7 | 14.16 | 1.39 | 15.36 | 1.32 | -2.4636 | 0.0199* |
| Day 0 to Day 2 | 0.75 | 0.39 | 0.71 | 0.27 | 0.2855 | 0.7773 |
| Day 0 to Day 7 | 0.09 | 0.08 | 0.27 | 0.20 | -3.3289 | 0.0024* |
| Day 2 to Day 7 | -0.66 | 0.40 | -0.44 | 0.27 | -1.7796 | 0.0856 |

*$p<0.05$

The above table shows striking difference in swelling measured from tragus to pogonion on day 2 and day 7 with the swelling in the experimental group being lesser. The swelling increased from day0 to day7 was considerably lesser in the experimental group.

The figure below compares the swelling measured from tragus of ear to pogonion at different time periods. The graph illustrates that the swelling in the post operative period was evidently more in the control group.

**Figure 4: Comparison of swelling using T-Pog scores in experiment group and control group at different treatment time points**




The table displays that the percentage of increase in swelling from day0 to day2 in both the groups, but the difference was not noteworthy. But the percentage of increase in swelling from day0 to day7 was definitely more in the no intervention group in contrast to the experiment group.

**Table 8: Comparison of swelling using T-Pog scores at different treatment time points in experiment group and control group by dependent t test**

| Groups | Time points | Mean | SD | Mean Diff. | SD Diff. | % of change | t-value | p-value |
|---|---|---|---|---|---|---|---|---|
| Experiment group | Day 0 | 14.01 | 1.37 | | | | | |
| | Day 2 | 14.76 | 1.24 | -0.75 | 0.38 | -5.35 | -7.9057 | 0.0001* |
| | Day 0 | 14.01 | 1.37 | | | | | |
| | Day 7 | 14.09 | 1.37 | -0.08 | 0.08 | -0.58 | -3.8961 | 0.0014* |
| | Day 2 | 14.76 | 1.24 | | | | | |
| | Day 7 | 14.09 | 1.37 | 0.67 | 0.39 | 4.53 | 6.9309 | 0.0001* |
| Control group | Day 0 | 15.09 | 1.34 | | | | | |
| | Day 2 | 15.80 | 1.19 | -0.71 | 0.27 | -4.72 | -10.7337 | 0.0001* |
| | Day 0 | 15.09 | 1.34 | | | | | |
| | Day 7 | 15.36 | 1.32 | -0.27 | 0.20 | -1.78 | -5.4936 | 0.0001* |
| | Day 2 | 15.80 | 1.19 | | | | | |
| | Day 7 | 15.36 | 1.32 | 0.44 | 0.27 | 2.81 | 6.5565 | 0.0001* |

*$p<0.05$

**MOUTH OPENING**

The mouth opening between both the groups at different time points was compared using independent t test. The mouth opening on day 2 and day 7 was significantly better in the group which received photobiomodulation as compared to the group which did not receive photobiomodulation.

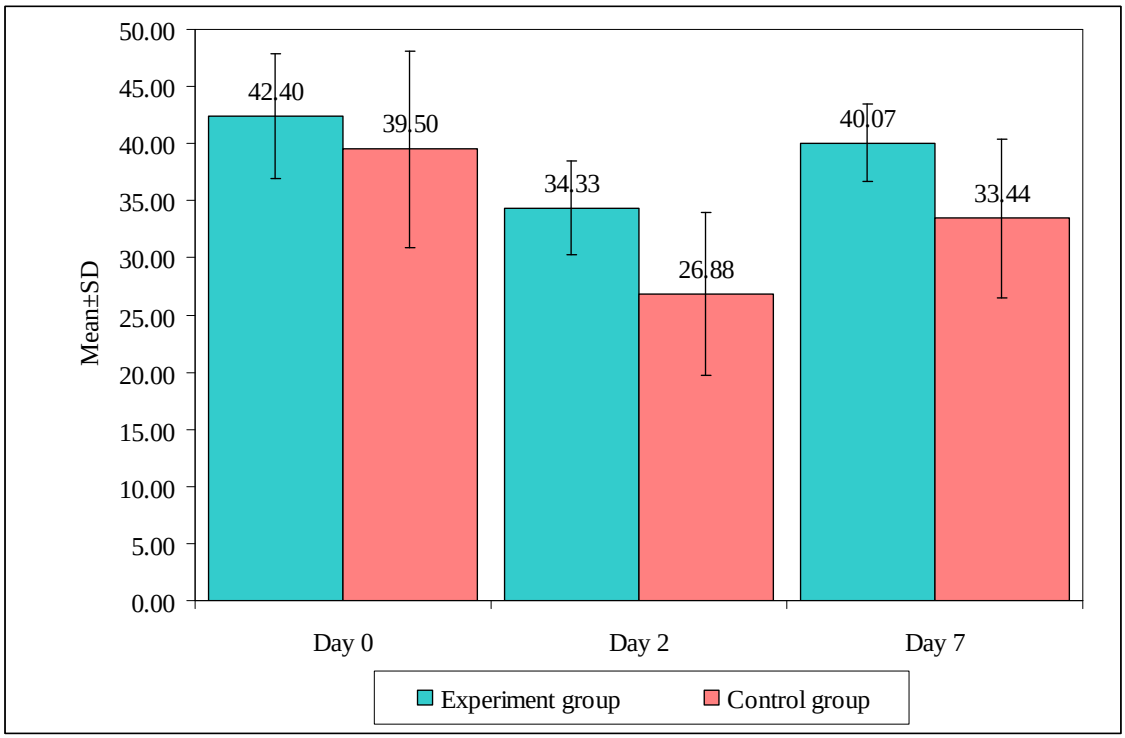
**Table 9: Comparison of mouth opening in experiment group and control group at different treatment time points by independent t test**

| Treatment times | Experiment group | | Control group | | t-value | p-value |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| Day 0 | 42.40 | 5.49 | 39.50 | 8.59 | 1.1118 | 0.2754 |
| Day 2 | 34.33 | 4.10 | 26.88 | 7.14 | 3.5356 | 0.0014* |
| Day 7 | 40.07 | 3.41 | 33.44 | 6.91 | 3.3506 | 0.0023* |
| Day 0 to Day 2 | -8.07 | 6.26 | -12.63 | 6.57 | 1.9744 | 0.0579 |
| Day 0 to Day 7 | -2.33 | 2.85 | -6.06 | 5.14 | 2.4736 | 0.0195* |
| Day 2 to Day 7 | 5.73 | 4.86 | 6.56 | 2.78 | -0.5877 | 0.5613 |

*$p<0.05$

The below figure depicts the mouth opening at various timeframes: day 0, day 2, and day 7 in both the groups. The improvement in mouth opening in experiment group was more on the 2nd day than in the controls. The mouth opening in the experiment group largely improved from day 2 to day 7.

**Figure 5: Comparison of mouth opening in experiment group and control group at different treatment time points**



# DISCUSSION

Pain, swelling and restricted trismus are the most frequently encountered and inevitable sequalae of surgical extraction of lower third molars[1]. These expected complications are commonly managed by pharmacological method or non-pharmacological methods. Pharmacological methods include oral analgesics, steroids as well as intravenous or intramuscular steroids[1]. The most common nonpharmacological method of reducing these complications is the local application of ice[25,26]. Though the pharmacological means are more effective in reducing these complications, they are associated with side effects[1]. Gastritis, systemic bleeding, and allergic reactions are some of adverse reactions that may be caused[31]. Photobiomodulation also called "Low Level Laser Therapy" (LLLT) is the newer non pharmacologic means of alleviating these common post-operative complications[31].

In this study photobiomodulation was given preoperatively, immediately post-operatively and on the second day post operatively. A total of 8 points: 4 intraoral and 4 extra oral points were irradiated. The results obtained in this study showed that pain in the control group was markedly more on the second- and seventh-day post operatively. The greatest improvement in mouth opening was seen on day 2 in LLLT group as compared to day 7 in the non-LLLT group.

## MECHANISM OF PHOTOBIOMODULATION[6]

The mechanism of action of photobiomodulation can be divided into two phases: primary and secondary. The primary phase is further divided into direct and indirect events. The interplay of biological tissues with radiant energy constitutes the directs events; whereas the indirect events are the events that follow the direct events.

The secondary phase comprises of the potent down stream biological responses that follow the primary phase. The primary phase is critical and transient for the photobiomodulation to act.

**PRIMARY PHASE**

It mainly involves the photophysical and photochemical events that occurring within a few seconds to few minutes of application. The primary photo acceptor plays the most crucial role in converting the irradiant energy. A functional protein and chromophore make up this photo acceptor. The photobiological responses are rapid and spatially limited because of their reactive nature; making the elucidation of these events extremely challenging.

**DIRECT PHASE OR SENSORS**

The absorption of photons generates photochemical intermediates, which are absorbed by a biological chromophore which leads to release of electron as a result of reduction oxidation reaction. Following this is the photomechanical change which change the conformation of the molecule, thus facilitating its physiological function. The above events occur in fraction of seconds. Dose-dependant detrimental damage may occur in case these reactions occur in excessive amounts.

**INDIRECT PHASE OR TRANSDUCERS**

The formation of biochemical intermediates along with the conformational changes starts the cascade of biological reactions which occur over a period of few seconds to minutes. Free radicals called ROS are formed after the transfer of electron to oxygen species. Electron transfer to nitrogen (N) leads to formation of nitrous oxide (NO) which in turn reacts with a product of inflammatory cells called the

superoxide anion. This results in formation of perioxynitrate which contributes to the anti-inflammatory effect of photobiomodulation. CCO is a component of respiratory chain present in the mitochondria is one of the photo acceptors of visible light. Maintaining the proton-motive force across the inner membrane of mitochondria is its key physiologic function. Increased ATP production results from the disrupted electron transfer process caused because of Photoabsorption by CCP. Photoabsorption also results in release of NO by CCO, which causes vasodilatation and cGMP mediated activation of Calcium sensitive potassium channels. This in turn promotes potent wound healing responses like endothelial migration, macrophage function, angiogenesis etcetera. In saline suspended human erythrocytes, photobiomodulation with 810 nm resulted in increased acetylcholinesterase (AChE) activity without disturbing the membrane electrochemical potential. Cell growth and differentiation is mediated by hemopoiesis and cell-cell interaction which are the key biological functions of erythrocyte AChE.

The role of TGFβ in proliferation, resolution, and remodelling of the wound tissue is of paramount importance as it promotes endothelial and fibroblast migration. Laser treatment is said to have a potent effect on the latent TGFβ1 complex which is liberally present in degranulated platelets following haemostasis. Secretion of Vascular endothelial growth factor (VEGF) and expression of HIF- 1a modulated by photobiomodulation in a dose dependant manner which improves healing by increasing the formation of new vessels.

**SECONDARY PHASE**

Secondary effector pathways involve transcriptional and translational responses which are induced after the initiation of the light-biological tissue interactions. This

phase takes several hours to days and often leaves an impact on the functional recovery. Photobiomodulation has the following roles in the phases of healing:

i. Haemostatic phase
    a. Encourages aggregation and activation of platelets
ii. Inflammatory phase
    a. Promotes rapid growth and degranulation of mast cells
iii. Proliferative phase
    a. proliferation of fibroblasts, keratinocytes, osteoblasts, and chondrocytes along with induction of matrix synthesis
iv. Maturation phase
    a. restores the functional architecture of tissue by enhancing the tensile strength which is improved because of reorganization and remodelling of wounds

**PHOTOBIOMODULATION TO ALLEVIATE POST OPERATIVE SEQUALAE OF SURGICALLY EXTRACTED IMPACTED MANDIBULAR THIRD MOLARS**

The wavelengths used to alleviate the post operative sequalae range from 650 to 980 nm[7]. In this study a diode laser was used with 940 nm continuous waveform both extra orally and intra orally at a total of 8 points:

**EXTRAORAL**

- At the angle of mandible
- One centimeter anterior to the angle of mandible
- Two centimeters anterior to the angle of mandible
- One centimeter above the angle of mandible

**INTRAORAL**

- On the buccal aspect distal to the first molar.
- On the buccal aspect 1centimeter distal to the first molar.
- On the buccal aspect 2 centimeters distal to the first molar.
- On the lingual aspect of the extraction socket.

Both intra oral and extra oral irradiation was given to patients as some stated extraoral application had better effects than intraoral[17] whereas some stated intra oral is better than extra oral[26]. Hence, it was decided to irradiate both extra orally and intra orally so as to obtain the best possible outcome.

Photobiomodulation was given pre operatively, immediate post-operatively and on post operative day two. Photobiomodulation was given preoperatively as preoperative application along with immediate post operative application gave better results in a study by Petrini et al[25]. As the swelling starts appearing only after 12-48 hours, it is important to provide another session of photobiomodulation on the second post operative day so the maximum benefit can be derived by the patient.

A study by Merigo et al[17] had used both super pulsed and pulsed 910nm along with 650 nm continuous waveform for photobiomodulation and reported significant difference in pain and swelling. Some of the studies[23,24,27,29] found photobiomodulation to be more effective in lowering the post operative pain than post operative oedema and discomfort. The results obtained in these studies were consistent with our results except that on our study not only pain but also mouth opening was markedly improved in the laser group. This may be contributed to the fact that LLLT is said to incite muscle relaxation especially if given before fatigue inducing exercises[25]. As in our study LLLT was also given preoperatively, it must

have had an effect on the relaxation of muscle resulting in much better mouth opening considerably earlier than the control group, contributing to better function and hence patient comfort. Though statistically the difference in swelling in both the groups was not much, it was definitely noticeable clinically. Also, extra oral application of LLLT is said to improve the mouth opening faster than intraoral application[11].

Most studies[1,5,10,12,18,21,22,25,28,32] reported no difference in pain, oedema and mouth opening after application of photobiomodulation. However, all these studies did not follow the same protocols neither in terms of the wavelength used nor in the terms of the points irradiated. All these differences may have contributed to the different results obtained in the various studies. The wavelength of light and whether it is used intra orally or extra orally has an impact on the results obtained. A study by Sierra et al[22] stated shallower depth of penetration is found with red photons and infrared photons are said to reach the deeper tissues. They advised that red light should be used intraorally, as it would act locally resulting in efficient local stimulation. The infrared light if used intraorally would pass through the affected tissue hence, would not have a local action. The red light if applied extra orally would fail to reach the muscles owing to its short depth of penetration and thus, infrared light would be more effective on extra oral application. Landucci et al[20] in their study advocated four intraoral and six extraoral points for irradiation immediately postoperatively that resulted in reduced pain, oedema and trismus immediately post-operatively and at 48 hours. However, in a study by Kahraman et al[26] intraoral low-level laser therapy was more helpful in alleviating post-operative pain than the extraoral group despite using a diode laser of 830 nm wavelength.

These studies also differed in the time frame when photobiomodulation was given. In a study by Petrini et al[25] the group given photobiomodulation before the surgical extraction leaded to significantly lesser consumption of analgesic in the post-operative period. In the same study both the laser groups (laser was given immediately post-operatively and after 24 hours in group1 and preoperatively and post operatively in group 2) had reduced swelling as compared to the control group who advised routine management with ice application.

A study by Markovic et al[9] in 2007 suggested that along with the application of photobiomodulation an intramuscular injection of 4mg of dexamethasone in the medial pterygoid significantly reduces the post operative swelling. The effect of photobiomodulation and use of intramuscular injection of 4mg dexamethasone in the deltoid region on swelling was found to be similar in this study. They concluded that there is no additional effect of systemic corticosteroids if photobiomodulation therapy has already been given.

Photobiomodulation in our opinion had a worthwhile effect on the overall quality of life of the patient. Not only was the improvement in mouth opening quick but overall patient comfort was enhanced in subjects who received the intervention. The improved mouth opening also helped the patient maintain normal diet. In certain case scenarios where analgesics have to be prescribed with precaution photobiomodulation can be an alternative/reduce the use of analgesics.

# CONCLUSION

This study was directed at evaluating the effect photobiomodulation given using 940 nm diode laser on reducing the post operative pain, swelling and trismus after third molar surgery. The study was done in the Department of Oral and Maxillofacial Surgery in K.L.E. Vishwanath Katti Institute of Dental Sciences from November 2019 to October 2021.

The surgical removal of lower third molar is the main livelihood of oral and maxillofacial surgeon. Various methods have been used in the past and still new methods are being sought to reduce the post operative discomfort, oedema and trismus arising after the surgical procedure. The newer method gaining popularity is photobiomodulation also called as Low-Level Laser Therapy (LLLT). Numerous studies have been conducted to evaluate the effect of photobiomodulation on reducing the post operative sequalae of third molar surgery. However, no common inference could be reached as the results obtained from these studies were mixed.

However, our study concluded that pain and trismus is significantly lesser when photobiomodulation is given preoperatively, immediate post operatively and on the second post-operative day. However, the reduction in swelling was not significant statistically but was clinically evident.

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# ANNEXURE I

# ETHICAL CLEARANCE CERTIFICATE

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**CERTIFICATE**

*This is to Certify that the synopsis titled*

THE EFFECTIVENESS OF PHOTOBIOMODULATION USING 940nm DIODE LASER FOR REDUCING PAIN, SWELLING AND TRISMUS AFTER THIRD MOLAR SURGERY : SINGLE BLINDED RANDOMISED CONTROL TRIAL

*Submitted by Dr.* RADHIKA . PATHAK *P. G. Student / Staff, Guided by* DR. TEJRAT. P. KALE *from Department of* ORAL & MAXILLOFACIAL SURGERY *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

**Date :**

**Member Secretary**
Research and Ethical Committee
KLEVK Institute of Dental Sciences
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Research & Ethical Committee
KLEVK Institute of Dental Sciences
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**Chairman**
Research and Ethical Committee
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# ANNEXURE II

# BIOSTATISTICS CERTIFICATE

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## *Biostatistics Clearance Certificate*

This is to certify that the Biostatistics aspect of the Dissertation / Research work of **Dr. RADHIKA PATHAK, Post Graduate Student**, under the guidance of **Dr. TEJRAJ P. KALE** M.D.S, **Professor, Department of Oral and Maxillofacial Surgery**, entitled **"The effectiveness of photobiomodulation using 940nm diode laser for reducing pain, swelling and trismus after third molar surgery: A Single Blinded Randomized Control Trial."** has been done under my guidance and considered satisfactory.

**Place:** Belagavi
**Date:** 06/12/2021

Name & Signature of Biostatistician
(Dr. S. B. Javali)

# ANNEXURE III

# PLAGIARISM REPORT

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## PLAGIARISM CHECK REPORT

Name of the Applicant : DR. RADHIKA PATHAK
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Batch & Year : 2019-22
Department : ORAL AND MAXILLOFACIAL SURGERY

The soft copy of Research Work / Manuscript by DR. RADHIKA PATHAK... entitled "THE EFFECTIVENESS OF PHOTOBIOMODULATION USING 940nm DIODE LASER FOR REDUCING PAIN, SWELLING AND TRISMUS AFTER THIRD MOLAR SURGERY - A SINGLE BLINDED RANDOMISED CONTROL TRIAL
under the guidance of DR. TEJRAJ P. KALE.....has been submitted for Anti-Plagiarism check to the Scientific Correspondence & Review Committee of KLE VK Institute of Dental Sciences using "Turn-it-in" software.

The scan has been carried out and the scanned output reveals a Similarity Index of .....4.....%, which is **within** / **not within** the acceptable limits of 10% as per the UGC guidelines.

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