"EFFECTIVENESS OF LOW-LEVEL LASER THERAPY IN ACCELERATING ORTHOONTIC TOOTH MOVEMENT IN MAXILLARY ANTERIOR CROWDING- A RANDOMIZED CONTROL TRIAL"

By

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Dissertation

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KAHER, BELAGAVI, KARNATAKA.

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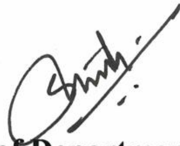

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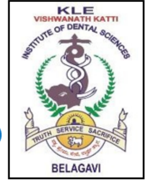

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ABSTRACT

Introduction: Orthodontic treatment plays a pivotal role in achieving functional and aesthetic dental alignment. However, prolonged treatment duration and associated discomfort remain significant concerns. Recent advancements in non-invasive techniques, particularly low-level laser therapy (LLLT), have shown promise in accelerating orthodontic tooth movement (OTM). LLLT is believed to enhance cellular activity, stimulate osteoclastic and osteoblastic functions, and reduce treatment time. While previous research has examined LLLT's efficacy, variations in laser parameters and irradiation protocols necessitate further investigation. This study aims to evaluate the effectiveness of LLLT in accelerating OTM during the initial levelling and alignment phase in patients with maxillary anterior crowding.

Materials and Methods: A randomized controlled trial was conducted on 24 patients requiring orthodontic treatment. Patients were divided into two groups: (1) Laser Irradiation Group (n=12) and (2) Control Group (n=12). A 970 nm diode laser with a power output of 200mW was applied at four points per tooth. The laser was administered every two weeks until alignment completion. Orthodontic treatment progress was measured using Little’s Irregularity Index (LII) on dental casts at baseline and subsequent intervals. Pain perception was assessed using the Visual Analog Scale (VAS) questionnaire. Data were analyzed using SPSS software, with statistical significance set at $p < 0.05$.

Results: Out of the 24 enrolled participants, 4 were lost to follow-up, leaving a final sample size of 20 (10 per group). Patients in the laser group attained alignment significantly faster (70.5 ± 10.12 days) compared to the control group (93 ± 9.48 days) ($p < 0.05$). The LII values showed a progressive reduction over time, with

significantly lower values in the laser group at critical time points (T3 and T4). Pain perception in the laser group was notably lower at weeks 2 and 4 ($p < 0.05$), indicating that LLLT alleviates early treatment discomfort. No adverse effects were reported, except minor gingivitis due to plaque accumulation.

Conclusion: The findings suggest that LLLT is a viable adjunct for accelerating tooth movement during orthodontic therapy. Patients treated with LLLT exhibited faster alignment and reduced pain in the initial stages of treatment. While the study confirms LLLT's potential, further research is required to optimize irradiation protocols and assess long-term clinical benefits. With proper standardization, LLLT could serve as a non-invasive solution to shorten orthodontic treatment duration and enhance patient comfort.

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INTRODUCTION

The rise in demand, particularly among young individuals, to have a pleasant smile with the help of orthodontic therapy is usually tested by its lengthy period and probable related discomfort. The last few years saw an enduring pursuit of a solid, realistic, and non-surgical solution which causes increase in rate at which of Orthodontic tooth movement (OTM) [1,2] occurs

Levelling an alignment are normally the initial or the first step in orthodontic treatment that can consume up to 8 months, depending on the severity of crowding of teeth [3,4]. Reduction in the time required for levelling an alignment by accelerating up OTM has been attempted successfully with methods like surgery involving micro-osteoperforation [5] corticotomy, piezocision and corticision [6]

Surgical procedures have been employed in the past to speed up tooth movement on the basis of regional acceleratory phenomenon or periodontally accelerated osteogenic orthodontics that provoked enhanced osteoclastogenesis leading to rapid tooth movement, but they were invasive and not well tolerated by patients.

This has therefore promoted the use of other techniques which are not as invasive, such as locally or systemically delivered pharmacotherapeutic agents' [7] application of equipment-assisted treatment like photomodulation with LED or laser-mediated treatment [8,9], with significant research backing the latter because it had successful outcomes and is non-invasive in nature. Low-level laser therapy (LLLT), is among the leading techniques currently, has an energy output low enough not to

induce any elevation of temperature of tissue which is under treatment above 36.5°C, or normal human temperature. [10]

Optimal wavelength for LLLT is not yet conclusively agreed upon, but most widely applied in dentistry is typically between 600–1000 nm and with power ranging from 50–200 mW. [11]

The enhancement in the orthodontic tooth movement linked to administration of LLLT is associated with remodeling of bone as the precursor cells exhibited an increased expression of RANK (Receptor Activator of Nuclear Factor Kappa-B) / RANKL (Receptor Activator of Nuclear Factor Kappa-B Ligand), hence an elevation in the number of osteoclasts as well as the osteoblasts present along with reinforcement of their functions [12].

Because of its effect that triggers remodelling of the tissue, the low-level diode laser irradiation has emerged as a potential non-invasive technique for speeding up tooth movement during orthodontic therapy. Furthermore, diode laser has been investigated in terms of analgesic applications, particularly as part of orthodontic treatment. [13]

Previous research has been extremely variable in terms of laser parameters and irradiation protocols. Also, previous studies concentrated more on the protocol's effectiveness and not on clinical significance. In fact, studies that were done earlier had lesser wavelengths ranging from 600 to 900 nm and the treatment of higher wavelengths applied in LLLT up to 980 nm has not extensively been examined. [14]

Although recent studies on rats have shown excellent results at these settings; furthermore, a wavelength of 970nm has shown that it penetrates better through the soft tissue to reach the underlying alveolar bone and periodontal ligament. [15]

Studies examining how photobiomodulation influences levelling and alignment in the anterior teeth in the lower segment have yielded contradictory results.

Few studies [16] did not discover any noteworthy effect of LLLT, compared to previous studies[17,18], which demonstrated a considerable decrease in orthodontic levelling an alignment duration by 26% and 25%. Along with this, literature has supported the analgesic role of LLLT by inhibiting the secretion of arachidonic acid derivatives in this case, prostaglandins, and endogenous opioid induction that caused severe analgesic effects. [19,20] However, some studies were unable to replicate these results

AIMS AND OBJECTIVES

AIM:

To evaluate the effectiveness of low-level laser therapy (LLLT) for accelerated tooth movement in maxillary anterior crowding

OBJECTIVES:

- To evaluate the rate of orthodontic tooth movement in maxillary anterior crowding using low level laser therapy
- To assess pain using the visual analogue scale (VAS) during levelling and alignment of maxillary crowding using LLLT method.

RESEARCH HYPOTHESIS:

Null Hypothesis- There is no difference in the rate of orthodontic tooth movement using low level laser therapy.

Alternate hypothesis- There is a difference in the rate of orthodontic tooth movement using low level laser therapy

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Turhani et al. (2006) [20]**:** This study assessed the efficacy of LLLT on orthodontic pain perception. The objective was to assess if laser therapy could provide a non-pharmacological pain relief option for patients undergoing fixed appliance therapy. The study demonstrated a noteworthy reduction in pain. In the group receiving laser therapy versus the control group.

The authors concluded that LLLT modulates inflammatory responses and inhibits nociceptive nerve conduction, making it a valuable adjunct for improving patient compliance at the time of orthodontic treatment therapy.

Youssef et al. (2008) [21]**:** The study was designed to determine the effect of LLLT on the rate of closure of space closure and to determine whether the application of LLLT increases the speed of tooth movement Having no negative impact on the surrounding periodontal tissues and to assess its influence on patient discomfort.

The study involved 20 patients undergoing canine retraction, the experimental group received a diode laser (810 nm) at 100 mW for 10 seconds per site every two weeks.

The rate at which the space closed increased by more than 30% when the LLLT group in comparison with the control, with no significant changes in root resorption or gingival health, indicating its safety and effectiveness in accelerating orthodontic movement.

Fujita et al. (2008) [22]**:** The study compared LLLT with corticotomy-assisted orthodontics to evaluate their effectiveness in accelerating tooth movement. The

objective was to determine whether LLLT could serve as a less invasive alternative to corticotomy.

LLLT had the distinct advantage of being non-invasive and painless. It demonstrated comparable results to surgical methods without the associated risks. The laser used stimulated bone remodeling by enhancing osteoclastic activity. The researchers emphasized the potential of LLLT as a preferred alternative to surgical techniques. This study contributed to early clinical evidence supporting non-invasive acceleration methods.

Yamaguchi et al. (2010) [23]**:** This study's aim was to investigate the molecular mechanisms through which LLLT accelerates orthodontic tooth movement. Objective was to analyze the expression of bone remodeling markers in response to laser therapy.

Their study showed that laser therapy upregulated RANKL expression, which is essential for osteoclast differentiation. Increased osteoclastic activity led to faster bone resorption and enhanced tooth movement. The findings established a direct link between LLLT and bone remodeling at the cellular level. The study offered evidence in favor of the clinical use of LLLT in orthodontics. It highlighted the importance of targeting cellular pathways to achieve therapeutic effects. These insights helped validate photobiomodulation as more than a mechanical stimulator.

Sousa et al. (2011) [24]**:** This study sought to evaluate the effect of LLLT on the initial alignment phase in orthodontic patients and whether LLLT can reduce the duration of initial alignment and to examine pain levels reported by patients after laser application. A sample of 30 patients with mild-to-moderate crowding received either

LLLT or a placebo. The LLLT group was treated with a GaAlAs laser, applied at specific points on the dental arch.

The LLLT group achieved alignment 25% faster than the control, and pain assessments using the Visual Analogue Scale (VAS) showed significantly reduced discomfort, highlighting its dual benefits

Bhad-Patil and Doshi-Mehta (2012) (11)**:** The study sought to find the impact of LLLT on reduction of orthodontic pain. The objective was to compare pain scores between laser-treated patients and those in a placebo group.

The laser-treated group consistently reported decreased pain related scores using the Visual Analogue Scale. LLLT was found to reduce the release of inflammatory mediators and enhance endorphin production. These mechanisms resulted in noticeable pain relief during orthodontic force application. The study confirmed the analgesic potential of LLLT in clinical orthodontics. It recommended LLLT as a valuable non-pharmacological adjunct for patient comfort.

Seifi et al. (2014) (25)**:** The study Focused on investigating the effect of LLLT and micro-osteoperforation in acceleration of orthodontic tooth movement. The purpose was to check whether LLLT could be a viable non-invasive alternative.

Both techniques significantly enhanced tooth movement, but LLLT was completely non-invasive and associated with minimal discomfort. The authors suggested that LLLT could be preferred for patients seeking non-surgical acceleration methods.

Long et al. (2015) (26)**:** The study investigated the role of LLLT in acceleration of orthodontic space closure. The objective was to measure the progression of space closure in laser versus control groups.

Patients undergoing LLLT showed a significantly faster rate of closure of space compared to controls. This study attributed the increased osteoclastic activity with balanced osteoblastic support, facilitating faster remodeling. Importantly, no adverse effects on periodontal health were observed. The results suggested that LLLT can enhance treatment efficiency without compromising biological safety. It also highlighted the benefit of LLLT in reducing overall orthodontic treatment duration. The study supported the use of laser-assisted therapy in conventional clinical practice.

Sousa et al. (2016) [27]**:** The study aimed at determination of the optimal laser settings for accelerating orthodontic tooth movement. The objective was to compare different wavelengths and energy densities. Medium-range energy levels (5–10 J/cm²) were the most effective.

Medium-range energy levels were said to be the best for accelerating tooth movement. Higher doses did not yield proportionate benefits and could delay movement. The study emphasized the importance of dose optimization to ensure clinical efficacy. It concluded that consistent protocols and personalized adjustments enhance outcomes. Their findings encouraged standardization of laser parameters for predictable results. The study emphasized the need for precise parameter selection to maximize clinical benefits.

Shaughnessy et al. (2017) [28]**:** Assessment of the impact of LLLT on orthodontic space closure along with alveolar remodeling of the bone. The study aimed to quantify the tooth movement under LLLT, also examine osteoclastic along with osteoblastic activity levels.

A split-mouth study was conducted on 15 orthodontic patients, with one side receiving an 808 nm laser with an energy which had a density of 6 J/cm² while the

other side served as a control. The LLLT-treated side showed a 40% increase in space closure rate. Histological examination revealed higher activity of osteoclasts during the phase of initial tooth movement, followed with enhanced osteoblastic activity, confirming that LLLT accelerates orthodontic tooth movement because it promotes bone remodeling.

Qamruddin I et al. (2017) [29]**-** They conducted A split-mouth randomized clinical trial to assess the impact of LLLT on orthodontic tooth movement and pain perception. This research involved 22 patients undergoing retraction of canine bilaterally with brackets that are self-ligating following premolar extractions. For each patient, one side received LLLT at 3-week intervals, while the other side or contralateral side served as a placebo. The laser-treated side demonstrated a significantly greater amount of canine movement compared to the control. Patients also indicated a marked decrease in lower pain scores on the laser side, especially during the initial phase of retraction. The authors concluded that LLLT has an impact in both accelerating tooth movement and decreasing associated discomfort. The study highlighted the importance of consistent laser parameters and interval-based application. It supports the clinical use of LLLT As a non-invasive complement to enhance treatment outcomes.

Ghaffar et al. (2021) [30]**:** Aim was to evaluate how LLLT has an effect on the rate of orthodontic tooth movement and levels of pain reported by patients. The objective was to assess if LLLT can be an effective complement to traditional orthodontic therapy by both acceleration of tooth movement and reducing discomfort. Results indicated LLLT significantly increased the rate of tooth movement while also reducing pain perception among patients.

The study concluded that LLLT could be a valuable non-invasive method to improve orthodontic efficiency and patient compliance, though further research is required to optimize dosage and application protocols.

Grajales et al. (2023): This research was aimed to evaluate what impact does LLLT have on orthodontic tooth movement in patients have canine retraction going on. The objective was to determine whether LLLT significantly increases tooth movement. The group treated with laser group showed a notable improvement in the rate of tooth movement. However, they noted variation in individual responses to LLLT. The study emphasized the need for personalized treatment protocols based on patient biology. No negative impact on gingival or health of periodontium were reported. It confirmed the safety of LLLT when used within standard clinical parameters. The authors called for further research to refine application intervals and energy settings.

MATERIALS AND METHODS

The current study was done to evaluate the rate of orthodontic tooth movement in maxillary anterior crowding using LLLT

STUDY DESIGN: Randomized control trial

SOURCE OF DATA:

Patients requiring orthodontic treatment reporting to The Department of Orthodontics and Dentofacial Orthopedics, KLE VK Institute of Dental Sciences, Belagavi. The study was done on pre-treatment and post treatment dental casts of patients and visual analogue scale (VAS)

MATERIALS AND ARMAMENTARIUM

- SiroLaser Blue diode laser, Dentsply Sirona (445nm, 660nm, 970nm wavelength) (figure 2)
- Dental Casts
- Digital caliper

INCLUSION CRITERIA

- Age group = 14 – 25 years
- Presence of all maxillary permanent teeth
- Patient having maxillary anterior crowding, with little’s irregularity index (LII) 4-6
- No long-term medications including nonsteroidal anti-inflammatory drug
- No previous orthodontic treatment
- Good oral hygiene, no gingival recession, no radiological evidence of periodontal problems

EXCLUSION CRITERIA

- Systemic disease or syndrome
- Abnormalities of teeth size/or shape
- Patient having compromised periodontal health

SAMPLE SIZE ESTIMATION

Sample size taken at 95% Confidence Interval, 5% Allowable Error and 10% Attrition

$$n= \frac{(Z_{1-\alpha/2} + Z_{1-\beta})^2 (SD_1^2 + SD_2^2)}{(\bar{x}1 - \bar{x}2)2}$$

Where,

SD_1= standard deviation of group 1

SD_2= standard deviation of group 2

$\bar{x}_1$= Mean of 1st group

$\bar{x}_2$= Mean of 2nd group

$Z_{1-\alpha}$= Alpha error at 5% (1.95 for 95% confidence interval

$Z_{1-\beta}$= Beta power at 90% (0.05 for 90% power)

Substituting the values in the above formula,

$n = (1.96 - 0.05)^2 ((4.4)^2 + (19.2)^2)$

$(98.2 - 78.9)^2$

Sample size = 10

Final Sample Sie with 10% attrition = 12 (each group)

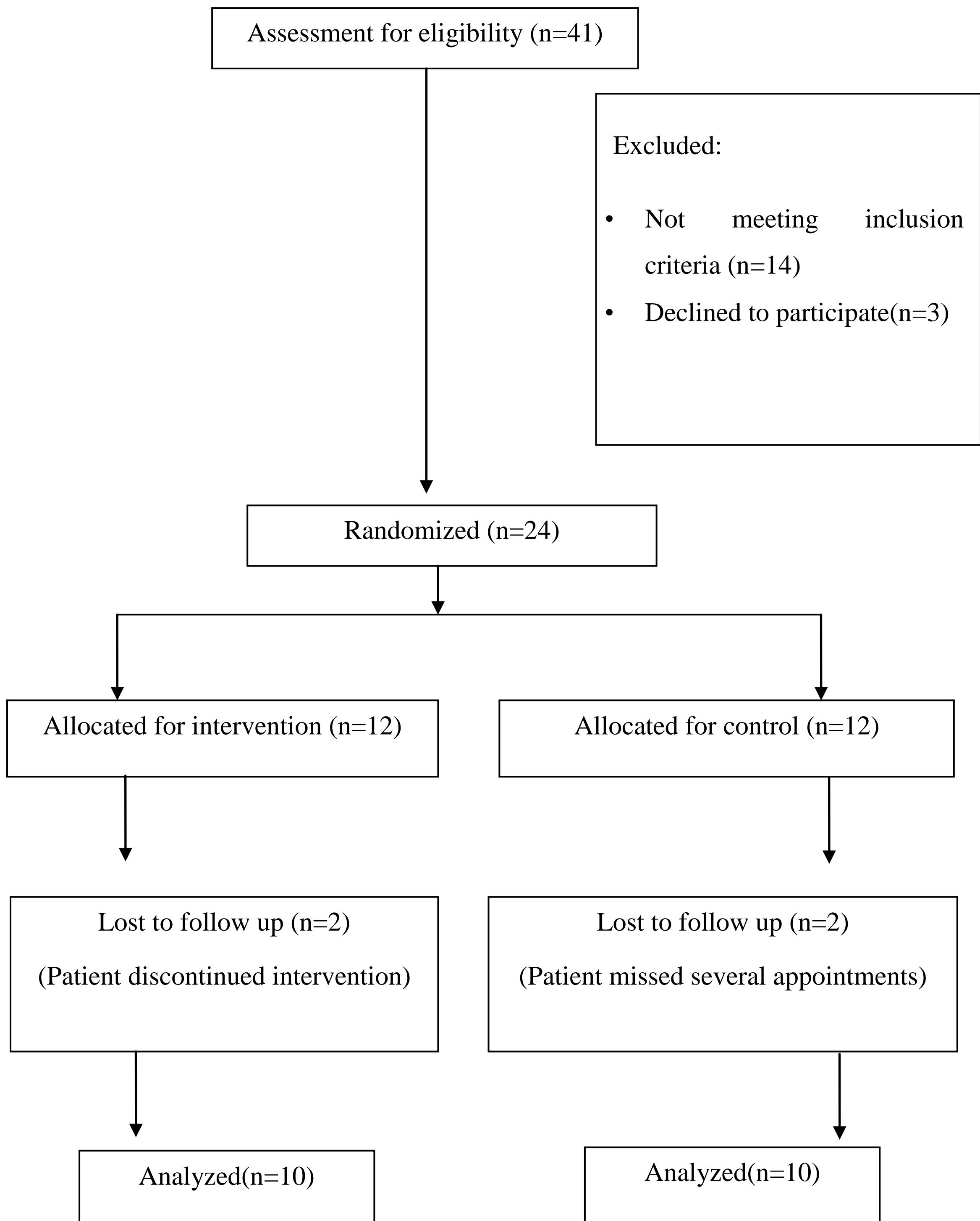
Total Sample size = 24 (2 groups)

The current study was a randomized control trial with a 1:1 allocation. The sample was divided into 2 groups-

- Group 1: Laser irradiation group
- Group 2: Control group

The CONSORT statement reporting guidelines were be followed

CONSORT FLOW DIAGRAM



The study was conducted in Department of Orthodontics and Dentofacial Orthopaedics and the Department of Conservative dentistry and Endodontics, KAHER's VKIDS, Belagavi, Karnataka

SUBJECTS

Patients reporting to the Department of Orthodontics and Dentofacial Orthopaedics, were recruited for the study. The rights of patients were protected, and the purpose and methods of the study was completely explained to the patients and the parents; an informed consent will be obtained from each.

RANDOMIZATION

Patients were divided into 2 groups of 12 each,

1. Group 1= Laser irradiation group
2. Group 2= Control group

Each patient was asked to select a folded piece of paper from a box containing 24 pieces of paper, on 12 of which the word ''laser'' was be written; on the other 12, the word ''control'' was be written

All patients underwent conventional fixed mechanotherapy with 0.022" X 0.028" MBT brackets.

Full pre-operative records were be taken, and teeth were be bonded using 3M Unitek MBT brackets for both groups

Leveling and aligning was achieved until 0.017" X 0.025" stainless steel wire

For Laser group, the laser group was exposed to biostimulation using 970 nm diode laser (SiroLaser Blue diode laser, Dentsply Sirona). Power output was 200mW. The areas exposed to irradiation included two doses on the coronal part of the root, with one on the buccal side and one on the palatal side, as well as two doses on the apical part of the root, with one on the buccal side and one on the palatal side. (figure 1)

Figure 1- Points of laser irradiation

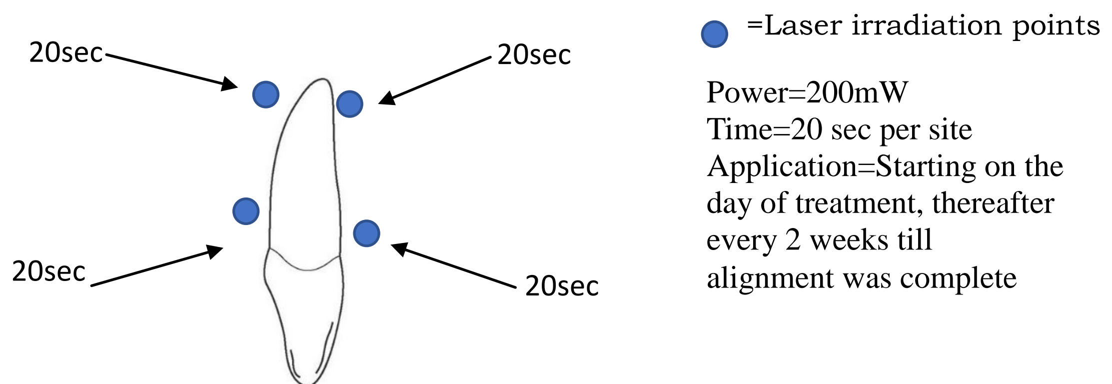
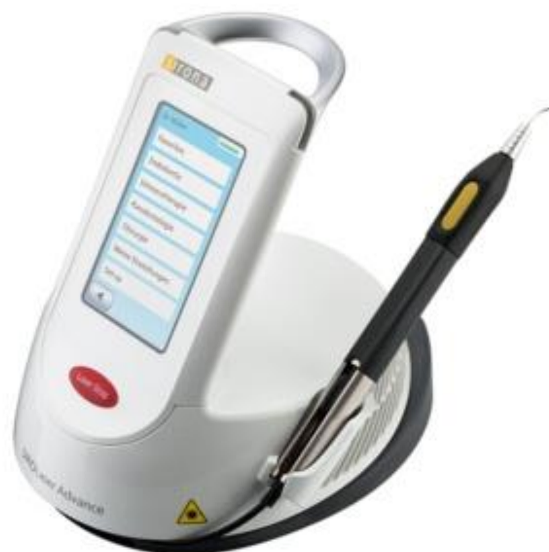
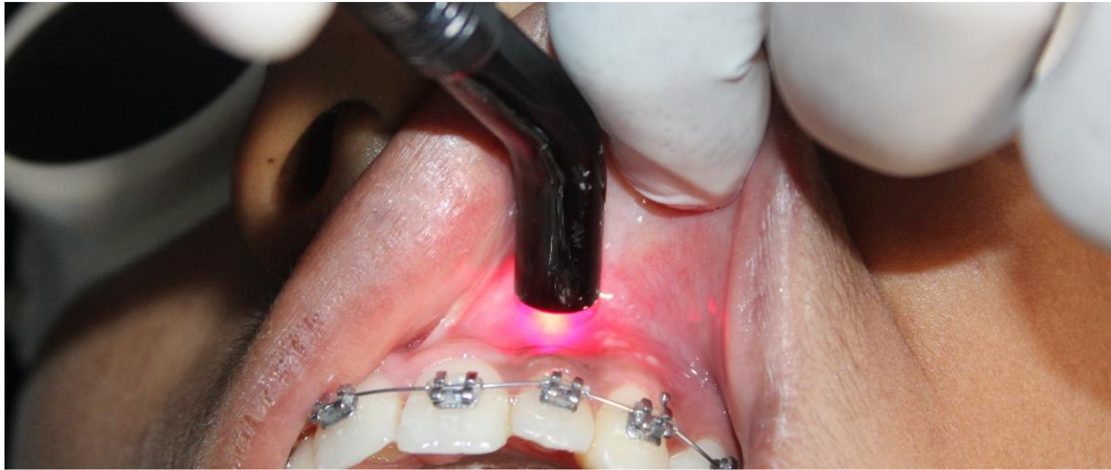


Figure 2- SiroLaser Blue diode laser, Dentsply Sirona



The LLLT was irradiated for 20 sec per site. Irradiation was performed by keeping the optical fiber tip perpendicular and in direct but light with mucosa. The laser irradiation was done on the day of starting treatment, followed by every 2-week interval till the alignment completion. (Till LII reaches less than 0.25mm)

Figure 3- Laser irradiation



For the control group, no intervention was be done. Patients underwent conventional fixed mechanotherapy with 0.022” X 0.028” MBT brackets.

Patients were called for normal appointments once every month for first 2 months and then every 2 weeks starting from the second month till completion of levelling & alignment (LII<0.25)

Records for both the groups consisting of photographs and maxillary alginate impressions were taken to make study casts at four time points:

1. Before insertion of the first archwire (T0),
2. After 1 month of treatment commencement (T1)
3. After 2 months (T2), and
4. At the end of the leveling and alignment stage (T3). (LII less than 0.25)

Figure 4- Little's irregularity index in upper arch

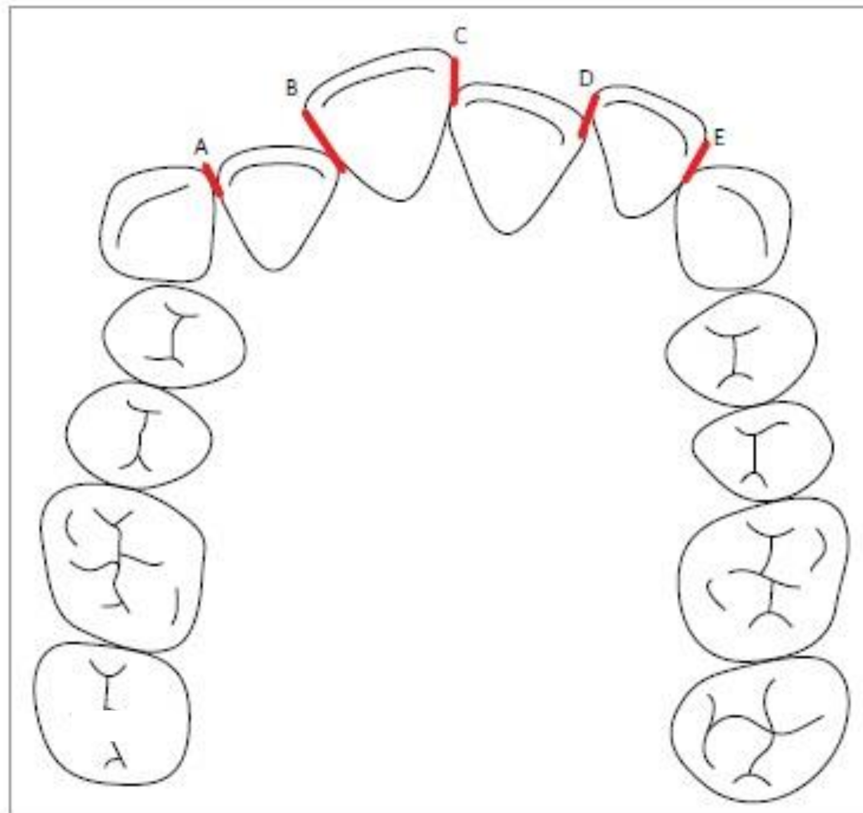


Figure 1 - Little's Irregularity Index for the Upper Arch: Sum of the distances A+B+C+D+E.

OUTCOME:

LII was used to measure the change in tooth alignment on the casts. It involved measuring the horizontal linear distance among adjacent contact points of the six anterior teeth. The sum of these five measurements gives the value of the index. LII was measured using a digital caliper.

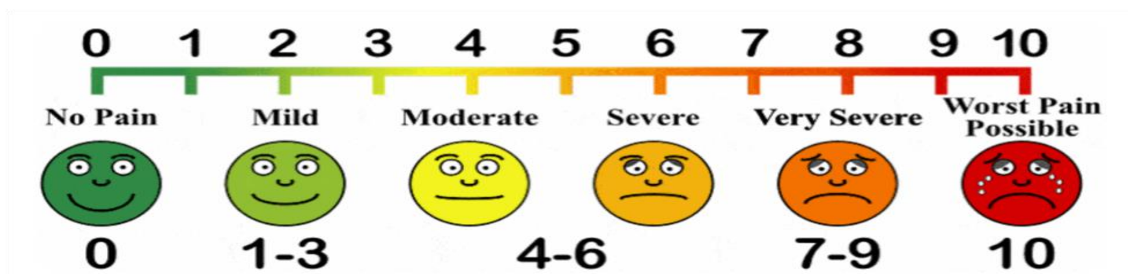
ASSESSMENT OF PAIN:

Pain was assessed using a visual analogue scale (VAS) questionnaire that was completed by the patient starting from the day following laser irradiation and was repeated every 2 weeks until the end of levelling and alignment.

For laser group, the VAS questionnaire was completed when the patients visited for the laser appointments every 2 weeks.

For the control group, the VAS questionnaire was completed when the patients visited for the normal appointment along with home questionnaires for every 2 weeks for first 2 months.

Figure 5- Visual analogue scale



STATISTICAL TESTS:

Study data obtained was entered to Microsoft Excel Software, which then was exported to Statistical Package for Social Sciences (SPSS) Version 25, IBM Statistics, USA.

- Descriptive Statistics (Mean, Standard Deviation) was obtained.
- Unpaired t-test/ Mann Whitney-U test for intergroup comparison between test and control groups.
- Repeated measures ANOVA test followed by Bonferroni's Post-Hoc test- Pairwise comparison for baseline to follow-up.
- Statistical significance was accepted at a confidence level greater than 95% ($p < 0.05$).

RESULTS

Forty-one patients with a mean age of 17.7 ± 2.91 years were first assessed for study eligibility. Seventeen patients, however, were deemed ineligible for inclusion in the study because of reasons such as severe crowding, medical history contraindications, or lack of consent.

So, twenty-four available patients were enrolled and randomly assigned in a 1:1 ratio to two groups, which were the laser irradiation group and the control group. These two groups contained twelve participants each. There were four losses of follow-up, two from each of the two groups, leaving the final sample size to be 20

The mean age of the laser irradiation group was 16 ± 2.21 and for control group was 19.4 ± 3.16 (table 1)

Table 1- Patient demographics

Groups	N	Male	Female	Mean age	Std. Deviation
Laser irradiation	10	4	6	16	2.21
Controls	10	2	8	19.4	3.61

Comparison of baseline pretreatment LII values between the control and laser groups did not show any statistically significant difference.

Mean preoperative LII value was measured as 5.18 ± 0.64 in the laser irradiation group and as 5.34 ± 0.47 in the control group ensuring both groups had similar initial maxillary anterior crowding levels. (table 2)

Table 2- Mean and Standard deviation of the Laser irradiation and control groups

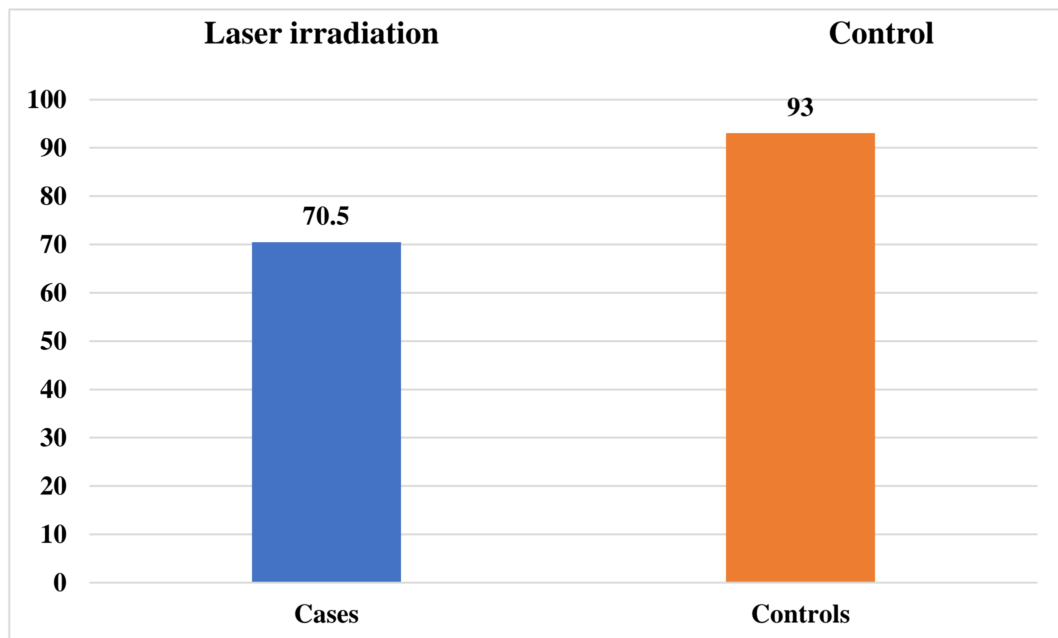
Groups	N	Mean	Std. Deviation
Laser irradiation	10	5.18	0.64
Controls	10	5.34	0.47

The LLLT patients attained alignment at a mean of 70.5 ± 10.12 days, whereas the control group had a mean of 93 ± 9.48 days to attain the same. (table 3, graph 1) Statistically significant difference ($P < .05$) between the groups was found, and it indicated that laser therapy accelerated the alignment process.

Table 3- Time required (in days) for completion of alignment

Groups	N	Minimum	Maximum	Mean	Std. Deviation
Laser irradiation	10	45.00	75.00	70.50	10.12
Control	10	75.00	105.00	93.00	9.48

Graph 1- Mean duration required for levelling and alignment in Laser irradiation and control groups



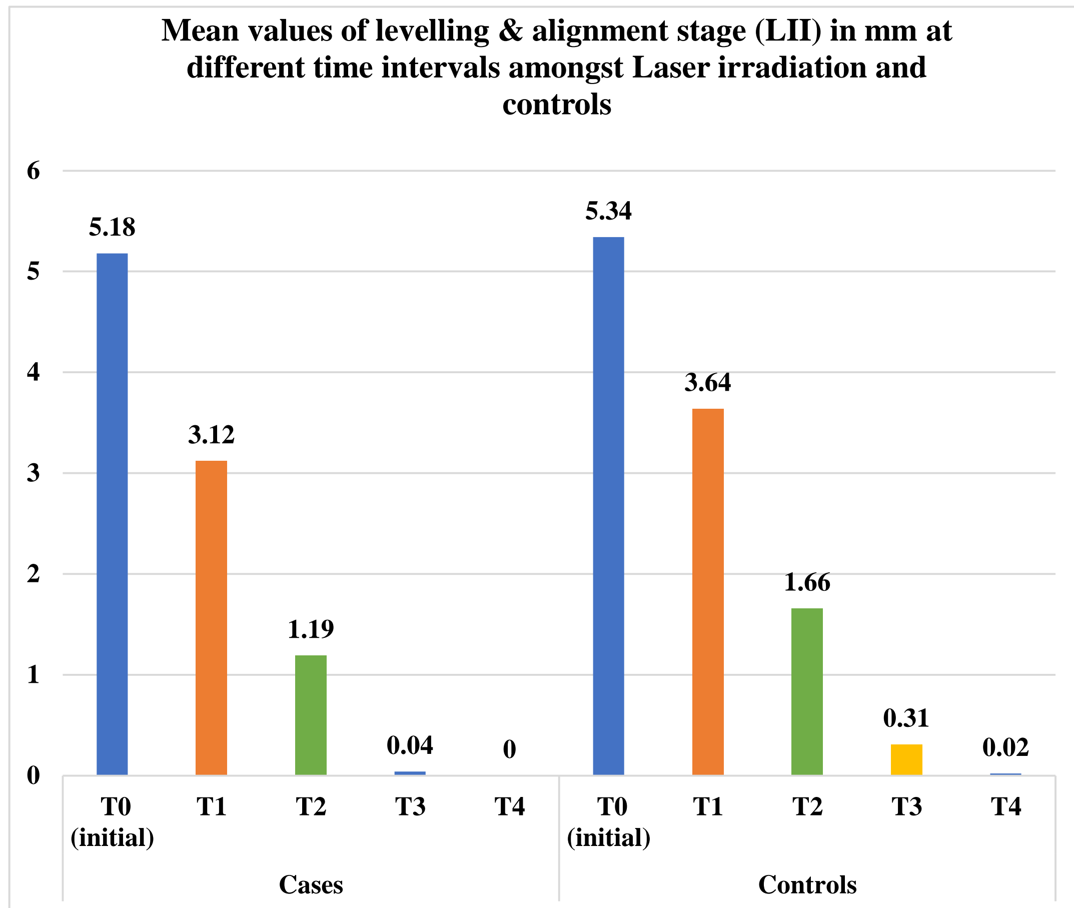
The result of the study showed a considerable decrease in mean orthodontic leveling and alignment time for the laser irradiation group compared to the control group.

Descriptive statistics showing mean and standard deviation values of laser irradiation and control groups are given in table 4. The table shows the mean and standard deviation values of LII at various time points of both the groups

Table 4 - Descriptive statistics of levelling & alignment stage (LII) in mm at various time points amongst Laser irradiation and control groups

Levelling & alignment stage (LII) in mm						
Groups	Time intervals	N	Minimum	Maximum	Mean	Std. Deviation
Laser irradiation	T0 (initial)	10	4.00	6.00	5.18	0.64
	T1	10	1.50	4.10	3.12	0.85
	T2	10	0.20	2.20	1.19	0.74
	T3	10	0.00	0.20	0.04	0.08
	T4	10	0.00	0.00	0.00	0.00
Control	T0 (initial)	10	4.60	6.00	5.34	0.46
	T1	10	2.80	5.20	3.64	0.69
	T2	10	1.00	3.00	1.66	0.60
	T3	10	0.00	1.40	0.31	0.49
	T4	10	0.00	0.20	0.02	0.06

Graph 2- Mean values of levelling & alignment stage (LII) in mm at various time points amongst Laser irradiation and control groups



The mean LII values showed a consistent reduction over time in both the laser irradiation and control groups, indicating progressive alignment. A more rapid decrease in LII was observed in the laser group compared to the control group across all time points.

Intergroup differences in leveling and alignment (LII) values were compared at various stages in time during the treatment period. The comparisons revealed statistically significant differences in the means ($P < 0.05$) at certain stages of examinations, especially the T3 (-0.270) and T4 (-0.020) time points. (table 5)

Table 5- Intergroup comparison of Levelling & alignment stage (LII) in mm between Laser irradiation and control groups at various time points

Comparison groups	Time intervals	Mean difference	t value	p value
Laser irradiation vs Control	T0(Initial LII)	-0.16000	-.631	0.536
	T1	-0.52000	-1.498	0.151
	T2	-0.47000	-1.541	0.141
	T3	-0.27000	-1.714	0.001*
	T4	-0.02000	-1.000	0.037*

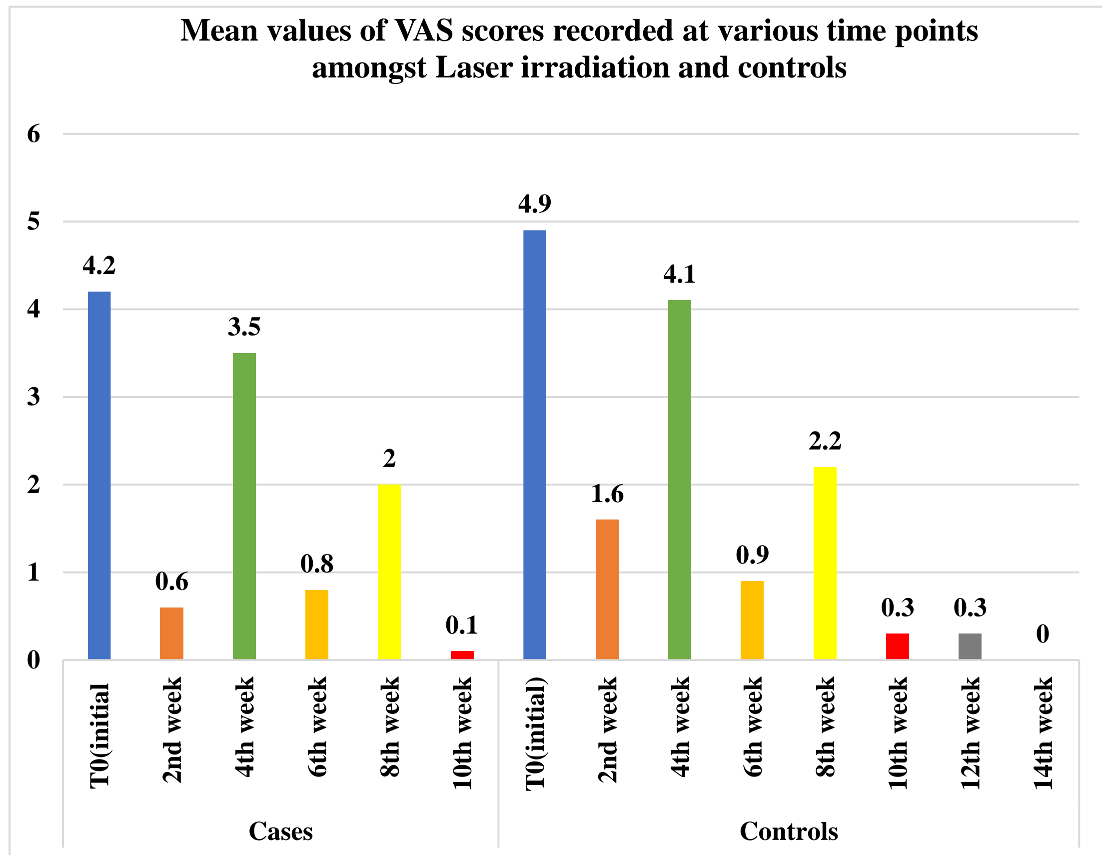
For pain sensitivity, Visual Analog Scale (VAS) measures were obtained at several points after the insertion of the first archwire.

The descriptive statistics showing mean and standard deviation for VAS scores for both the groups are given in table 6 and graph 3

Table 6 - Descriptive statistics of VAS scores recorded at various time points amongst Laser irradiation and control groups

VAS scores						
Groups	Time intervals	N	Minimum	Maximum	Mean	Std. Deviation
Laser irradiation	T0(initial	10	3.00	6.00	4.20	1.03
	2nd week	10	0.00	2.00	0.60	0.84
	4th week	10	3.00	4.00	3.50	0.52
	6th week	10	0.00	2.00	0.80	0.78
	8th week	10	1.00	3.00	2.00	0.47
	10th week	10	0.00	1.00	.10	0.31
Control	T0(initial)	10	4.00	6.00	4.90	0.73
	2nd week	10	0.00	3.00	1.60	1.17
	4th week	10	3.00	5.00	4.10	0.73
	6th week	10	0.00	2.00	0.90	0.87
	8th week	10	1.00	3.00	2.20	0.78
	10th week	10	0.00	1.00	0.30	0.48
	12th week	10	0.00	1.00	0.30	0.48

Graph 3- Mean values of VAS scores recorded at various time points amongst Laser irradiation and control groups



The VAS scores demonstrated an overall declining trend in pain perception during the levelling and alignment phase in both groups. By the 2nd week, a statistically significant reduction in pain was observed in the laser group (mean = 0.60 ± 0.84) compared to the control group (mean = 1.60 ± 1.17), $p < 0.05$.

At the 4th week, both groups exhibited a peak in pain scores; however, the laser group continued to show lower values (3.50 ± 0.52) than the control group (4.10 ± 0.73), with the difference being statistically significant ($p < 0.05$).

Intergroup comparison of VAS scores between Laser irradiation and Controls at various time points showed statistically significant differences (p value <0.05) at 2nd and 4th week between laser irradiation and control groups.

Table 7 – Intergroup comparison of VAS scores between Laser irradiation and control groups at various time points

Comparison groups	Time intervals	Mean difference	t value	p value
Laser irradiation vs Control	T0(initial pain)	-0.70000	-1.744	0.098
	2nd week	-1.00000	-2.188	0.042*
	4th week	-0.60000	-2.092	0.05*
	6th week	-0.10000	-0.268	0.791
	8th week	-0.20000	-0.688	0.091
	10th week	-0.20000	-1.095	0.071

However, in the subsequent weeks no statistically significant difference was found This indicates that laser therapy may have a greater impact on reducing pain in the early period of orthodontic treatment but not throughout the course. (table 7) No serious harm was observed other than gingivitis associated with plaque accumulation.

DISCUSSION

Main downside of orthodontic procedure is pain and prolonged treatment duration following application of forces [26]. The leveling and alignment stage constitutes a major phase of orthodontic treatment. [30]

The goal of the study was to evaluate the effectiveness of LLLT in accelerating orthodontic tooth movement for levelling and alignment of dental crowding cases and to check the associated pain. It focused on anterior tooth alignment as a key factor in evaluating tooth movement and determining the required treatment duration.

Low-level laser therapy has shown promise as an adjunctive technique in orthodontics, particularly for accelerating tooth movement and modulating pain and inflammation. [32] The effects of LLLT are based on photobiomodulation, where specific wavelengths of light, typically in the red or near-infrared spectrum [33], stimulate cellular activity, leading to enhanced mitochondrial activity, ATP production, and increase in the activity of osteoclasts and osteoblasts [34]. This mechanism can theoretically promote faster bone remodelling, which is essential during orthodontic tooth movement. [35]

In previous studies [9,17], the mean time required to finish leveling and alignment varied between 104 and 109 days. The current study showed that the mean time required for completion of levelling and alignment was 93.00 ± 9.48 for the control group and 70.5 ± 10.12 for the laser irradiation group (table 3). The laser irradiation group demonstrated a notably shorter duration for alignment completion compared to the controls, highlighting a potential acceleration in treatment progress.

This was comparable to previous studies which showed similar duration for levelling and alignment. Some variation might be due to the differences in baseline in LII, which ranged from n 5.8 ± 6 1.6 mm, up to 10.8 ± 2.29 mm. [17]

The Little's Irregularity Index was used to quantify crowding and monitor the progress of alignment one month interval from the baseline (T0), i.e. before insertion of the first archwire. Both groups showed a progressive reduction in LII values, indicating successful alignment over time. However, intergroup comparison revealed statistically significant differences favoring the LLLT group at T3 ($p = 0.001$) and T4 ($p = 0.037$). (table 5)

As the intergroup comparison between the laser irradiation and the control group suggests, the acceleration was significantly better in the later stages of levelling and alignment in the laser irradiation group. These findings align with a study conducted by one study [30] where there was significant improvement after 2nd month of treatment commencement

Effectiveness of Low-Level Laser Therapy in accelerating tooth movement and reducing associated pain has been previously studied extensively. [1,37,38,39,40,41] However, the results have not been consistent and cannot be generalized because of variation in parameters of laser—wavelength, power density, energy density, duration of treatment, and mode of delivery—and in samples and orthodontic treatment employed.

The energy density calculated in the current study was 5 J/cm^2 per treatment (4 J per point), one author [38] proposed doses of energy densities of 2.5–8 J/cm^2 compared to higher ones (20 and 25 J/cm^2 or more) for accelerating tooth movement. However, they stressed the uncertainty of the optimal dose.

On the other hand, another study [42] employed 2 J per tooth with a total energy of 12 J per session; however, a small effect of LLLT on alignment was seen.

In contradiction, findings of this study did not concur with one author's [42] work with 25 J/cm^2 density of LLLT where they concluded that LLLT density was most likely too low to exert either stimulatory or inhibitory effect on OTM rate.

Laser power output was 200mW and tip utilized was normal fibre optic tip for laser irradiation in this study. Laser irradiation was applied at 4 points, 2 buccal and 2 palatal, which were similar to a study [8] where there were four application points for each tooth (two on buccal surface and two on palatal surface). Facial and lingual application were also done at 10 points per tooth in one study [42]

Laser-assisted orthodontic levelling and alignment time (OLAT) in the earlier studies varied from 48 to 211.8 days. [16, 18] OLAT in this study for the laser group showed better results when compared with that reported by a study [18] from their 26%-time reduction in their study compared with 24% in the present study, which was similar. Inconsistency of findings among the studies may be due to differences in laser parameters that were employed and intervention schedule of laser along with differences in the order of sequence of archwires employed.

When the intergroup comparison was made of the two study groups (Table 5), it became clear that the laser group had significantly improved alignment beginning in the second month. The findings of one study [28] highlighted the effect of LLLT, especially from the third month, supported the results. They clarified that an increase in orthodontic tooth movement following laser irradiation could be attributed to an increase in osteoclast activity and/or number in the laser-treated area through

activation of the RANK/RANKL/OPG system, which is crucial for bone remodeling. [28]

A number of studies have documented LLLT use to enhance analgesia. In line with earlier studies [42], no statistically significant difference in pain scores between groups was found in the current study. However, at the 2nd and 4th week, laser irradiation group had statistically significantly lower mean pain scores compared to the control group.

The outcomes indicated that patients who received laser therapy experienced significantly less pain than the control group patients at weeks 2 and 4 of treatment. But during subsequent follow-up, i.e., at weeks 6, 8, and 10, no significant differences in pain perception between the two groups were noted (table 7)

This shows that LLLT might be beneficial for alleviating pain in the initial stages of levelling and alignment, but there is no statistically significant difference in the consecutive appointments. However, further studies might be required with different parameters as LLLT shows promise for pain relief.

Though evidence of marked potential of LLLT in reducing OLAT and related pain was reported, advantages of reduction in treatment time can be negated by total number of visits required for laser application. Thus, additional research may be required to optimize laser application protocols.

CONCLUSION

Despite the current limitations of the study, the findings provide substantial evidence for LLLT's role in accelerating orthodontic tooth movement, making it a promising adjunct to traditional treatments. While the therapy does not impact pain levels, its efficacy in reducing alignment duration makes it a valuable tool for clinicians seeking to optimize treatment efficiency. Further research should aim to refine LLLT protocols and explore its long-term impact on orthodontic outcomes.

SUMMARY

Orthodontic treatment is increasingly sought by young individuals for improved dental aesthetics and function. However, the prolonged duration of treatment, especially during the initial leveling and alignment phase, often leads to decreased patient compliance and increased discomfort. Traditionally, surgical methods like corticotomy and micro-osteoperforation have been used to accelerate orthodontic tooth movement, but their invasive nature limits patient acceptance. As a result, non-invasive methods such as Low-Level Laser Therapy (LLLT) have gained attention in recent years. LLLT, through photobiomodulation, stimulates cellular metabolism, enhances ATP production, and promotes bone remodeling by increasing osteoclastic and osteoblastic activity. The most effective wavelength for LLLT in orthodontics is not yet standardized, though wavelengths between 600–1000 nm have shown promising results. A 970 nm diode laser offers deeper tissue penetration, targeting the periodontal ligament and alveolar bone more effectively. Previous studies have shown mixed results regarding LLLT's efficacy, likely due to variations in laser parameters, application protocols, and sample characteristics. Therefore, this study aims to evaluate the clinical effectiveness of LLLT at 970 nm in accelerating tooth movement and reducing pain during the alignment of maxillary anterior crowding.

Aim: To evaluate the effectiveness of Low-Level Laser Therapy (LLLT) for accelerated tooth movement in maxillary anterior crowding

Materials and Methods: A randomized controlled trial was conducted on 24 patients aged 14–25 years, divided equally into two groups:

Group 1: LLLT group

Group 2: Control group

Patients underwent fixed appliance treatment using MBT 0.022” brackets. The LLLT group received 970 nm diode laser irradiation (200 mW, 20 seconds per site) every two weeks until alignment completion.

Tooth alignment was measured using Little’s Irregularity Index (LII) at baseline, 1st month, 2nd month, and upon completion of alignment. Pain levels were recorded using VAS at 2-week intervals.

Results: The LLLT group achieved alignment significantly faster (mean = 70.5 ± 10.12 days) compared to the control group (mean = 93 ± 9.48 days). Pain scores were significantly lower in the LLLT group during the 2nd and 4th weeks. No adverse effects were reported, except minor gingivitis related to plaque accumulation. Statistically significant improvement in LII reduction and pain control was observed in the laser group compared to control at specific time intervals.

Conclusion: Low-Level Laser Therapy (LLLT) demonstrated a significant effect in accelerating tooth movement and reducing pain during the initial phases of orthodontic treatment. It is a promising, safe, and non-invasive adjunctive technique that can enhance treatment efficiency and patient comfort. Further studies are recommended to optimize its application protocols.

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ANNEXURES

ANNEXURE – I ETHICAL CLEARANCE

Research and Ethics Committee
KLE VK INSTITUTE OF DENTAL SCIENCES
A Constituent Unit of KLE Academy of Higher Education & Research
Accredited 'A' Grade by NAAC Placed in Category 'A' by MHRD (GoI)
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Sl. No. : 1658

CERTIFICATE

This is to Certify that the synopsis titled

"Effectiveness of low-level therapy in accelerating orthodontic tooth movement in maxillary anterior crowding - A Randomized controlled Trial"

Submitted by

Dr. **REG. NO. II0222005** *P. G. Student / Staff, Guided by* *from Department of* Orthodontics & Dentofacial Orthopaedics. *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 16/4/25

Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

MEMBER SECRETARY
Research & Ethical Committee
KLEVK Institute of Dental Sciences
BELAGAVI.

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

Chairman
Research and Ethical Committee
KLE VK Institute of Dental Science
Belgaum

ANNEXURE II-

CONSENT FORM

KLE UNIVERSITY'S KLE VK INSTITUTE OF DENTAL SCIENCES, BELAGAVI –590010.

Effectiveness of Low-level laser therapy in accelerating orthodontic tooth movement in maxillary anterior crowding: A Randomized control trial

OPERATOR: DR. KRISH RAICHURA

PURPOSE OF THE STUDY:

You are invited to take part in a clinical study. But before you accept, we would like to help you understand the study and what participation you will be involved in. We are conducting a study to assess the effect of low-level laser on the rate of orthodontic tooth movement

NEED FOR THE STUDY:

Long duration of orthodontic treatment is a major concern for patients as fixed appliance treatment can take up to 2 to 3 years, including a follow-up period for retention. This long duration of treatment may take its toll on the tooth supporting structure like periodontal ligament, dentin, cementum and alveolar bone. In addition, the clinician loses on patient compliance due to a longer duration of treatment time.

The increasing demand, especially among adults, to attain a pleasing smile through orthodontic treatment is usually challenged by its long duration and possible associated discomfort. The last decade has witnessed a persistent quest for a reliable, practical, and minimally invasive approach for acceleration of orthodontic tooth movement (OTM).

The application of low level laser therapy (LLLT) in orthodontics has shown to be effective in reducing orthodontic pain and that might accelerate orthodontic tooth movement[2].

A wavelength of 600–1000 nm provides a proper photo- bio-modulation affect because at this wavelength absorption of the light by haemoglobin and water is low, that allows for proper penetration of the laser beam into the tissues and proper stimulation of bone cells.

Previous studies have been conducted with lower wavelengths (from 670 to 904 nm), and treatments with higher wavelengths applied during (LLLT), which goes up to 980 nm, have not been well studied.

However, recent studies on rats have shown encouraging results at these settings; furthermore, a wavelength of 970nm allows deep penetration through soft tissue to reach alveolar bone and the periodontal ligament.

AIM OF THE STUDY:

To evaluate the effectiveness of low-level laser therapy (LLLT) for accelerated tooth movement in maxillary anterior crowding.

OBJECTIVES:

- To evaluate the rate of orthodontic tooth movement in maxillary anterior crowding using low level laser therapy
- To assess pain using the visual pain analogue scale during levelling and alignment of maxillary crowding using the low-level laser therapy method

Signature of the participant :……………… Signature of the researcher:…………….

Date:………………

Place:………………

ANNEXURE-III

PROCEDURE OF THE STUDY:

If you choose to participate, you will be given laser irradiation around the maxillary teeth with an interval of every 2 weeks starting from the day of treatment.

The procedure will be carried out by a highly skilled professional. There will be no adverse effects after the procedure. You will not be allowed to take any pain medications throughout the procedure unless absolutely required

I, ____ aged ______________ have been informed about my involvement in the study:

1. I agree to give my personal details like name, age, sex, address, and the details required for the study to the best of my knowledge.
2. I am informed about the procedure that I will be undergoing.
3. I permit the orthodontist to utilize the information given by me and results obtained from this study for presentation and publication purpose.
4. I will not claim any returns for my cooperation in the study, even if it is being sponsored by any agency. I am participating with my own will and wish.
5. I will follow the instructions given by the orthodontist.
6. During the study, if I wish to resign, I am free to do so and my treatment will still be completed in the department.

In my full consciousness and presence of mind, after understanding all the procedure in my vernacular language, I am willing and give my consent to participate in this study.

Date:

Place:

Subject's Signature   Signature of witness

ANNEXURE-IV PHOTOGRAPHS