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Application Of Diode Laser In Mitigating Endodontic Pain- A Systematic Review And Meta Analysis

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Abstract: Introduction
Diode laser has been used in dentistry it exerts neuron- regenerative and anti-inflammatory effects to provide pain control. It's application with low level lasers parameters causes insignificant thermal changes and elicits bio modulatory effects.
Aim
The study aim to examine the effectiveness of the diode laser in reducing post-operative pain during endodontic treatment and retreatment operations, as well as to discuss the numerous prognostic variables related to the chosen treatment approach.
Material and Methods
The results of 8 research were incorporated in the current systematic review and meta-analysis. Articles describing effect of diode laser therapy on postoperative endodontic treatment and re-treatment that were published between January 2011 to May 2021 were searched in MEDLINE (Pubmed), Cochrane Central Register of Controlled Trials (Central) and EMBASE databases. References of articles included were checked manually
Results
Since the average statical diamond is towards the diode laser group so the mean difference between the experimental group and control group. The pooled average difference between the test group and control group was estimated to be 0.-0.50 at 95% CI (-0.84 to -0.16). Day 7 of pain evaluation favors the experimental group.
Conclusion
Endodontic retreatment involves a series of complex processes, where the finding of diode laser to be used subsequently as routine chemo-mechanical procedure for disinfection can efficiently reduce pain and provide comfort to the patient after endodontic treatment and retreatment.

Keywords: Endodontic pain, Diode laser, Root canal irrigant, Visual analogue scale.

1. Introduction

The development of a sterile, bacteria-free environment within the tooth and at the apical region of the tooth, involving the periodontal tissue and the adjacent apical bone, is the therapeutic objective of endodontic therapy in cases of necrotic teeth with persistent periapical diseases.1

There have been studies into various postoperative endodontic pain management techniques. Sodium hypochlorite (NaOCl) is one of the most often utilized irrigate due to its widespread antibacterial action and capacity to dissolve organic debris. Other irrigates include corticosteroids and nonsteroidal anti-inflammatory medications (NSAIDs).2

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According to Grossman, a diode laser is a solid-state semiconductor laser which emits light with a wavelength of 800-980 nm by combining aluminum, gallium, and arsenide. By means of the ability of light that activates host cells, diode laser treatment has been used in the field of dentistry for the purpose of analgesia, inflammation modulation, and tissue healing. The analgesia generated by it results from various biological mechanisms, like vasodilation, a rise in adenosine triphosphate and cortisol levels, and restricting the generation of inflammatory factors.3

Since its introduction in dentistry in 1971, diode laser therapy has been used to reduce pain by promoting neuronal regeneration and reducing inflammation. When used with low level laser settings, it produces little thermal changes and biomodulatory effects.4

Diode laser treatment lessens post-operative discomfort in mandibular molar teeth with symptomatic apical periodontitis that have undergone endodontic root canal therapy.4-6 When contrasted to mock laser therapy, recent studies by Asnaashari M et al and Aggarwal et al reported the utility of diode laser in the treatment of post endodontic pain.7,8 Based on the notion that microbial infections are the most frequent causes of pain. In order to analyze and debate the effectiveness of laser therapy, a thorough systematic review and meta-analysis examining the efficacy and use of diode laser for postoperative endodontic pain following root canal treatment, root canal retreatment, would be a realistic approach.

This systematic review and meta-analysis's objectives were to examine the effectiveness of the diode laser in reducing post-operative pain during endodontic treatment and retreatment operations, as well as to discuss the numerous prognostic variables related to the chosen treatment approach. The results of 8 research were incorporated in the current systematic review and meta-analysis.

2. Methodology

This systematic review was carried out and registered in Prosper under the registration number CRD42021257253 and adhered to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) standards.

Searches were conducted in the MEDLINE (Pubmed), Cochrane Central Register of Controlled Trials (Central), and EMBASE databases for articles describing the effects of diode laser therapy for postoperative endodontic treatment and re-treatment. The included papers' references were manually examined.

Inclusion criteria:
Studies that include patients requiring endodontic treatment using diode laser therapy. Age of the patients will be from 18 – 80 years. Studies published in English language only. Studies including only randomized control trials. Studies published from January 2011 – May 2021

Exclusion criteria:
Studies other than endodontic treatment. Studies showing root canal disinfection by diode laser and did not include the criteria for endodontic pain. Ineligible study type, sample overlap, without access to full text. Articles other than English. Literature review, case reports, pilot study, prospective and retrospective studies. Studies with a drop- out rate higher than 30%.

Search strategy
PUBMED, Cochrane Central Register of Controlled Trials, Science Direct, and Google Scholar were the four online databases that were electronically searched. The following search phrases were employed:

We also used population, intervention, comparison and outcome (PICOS search strategy including a combination of key words and our MESH terms. The following MESH terms, search terms, and their combination were used in the search:“Post endodontic pain” AND “retreatment pain” AND “diode laser” AND “laser therapy” AND “photodynamic therapy” AND “Endodontic pain” AND “root canal treatment” AND “root canal disinfection” OR “root canal irrigation” AND “numerical rating scale” OR “ visual analogue scale

Data extraction
Two reviewers (NS, RR) independently examined titles and abstracts to choose the studies. The full-length text of each qualifying article was then extracted and independently reviewed by the same two reviewers. The study's author was contacted via email to give any missing information. Author, published year, research design, follow-

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up length, participant count, age, intervention, control group, outcome, and measurement techniques were all taken out of each study.

Risk of bias assessment
Quality assessment of the included studies was performed by two independent reviewers (NS AND RR) using the REVMAN 5 review manager 5.4.1 Collaboration's tool for assessing the risk of bias.

Any disagreement between the reviewers during risk of bias evaluation were resolved through discussion, and if necessary, consulting a third reviewer (AJ).

The following criteria were used to assess the risk of bias using Random sequence generation; Allocation concealment; Blinding of participants and personnel; Blinding of outcome assessment; Incomplete outcome data; Selective reporting; Other bias.

If blinding was applied for patients, the domains "blinding of participants and personnel" and "blinding of outcome" were considered low risk since the operator cannot be blinded to the procedure and the patients themselves recorded their pain experience on a visual analogue scale (VAS).9

Statistical analysis
The information gathered from the articles' entire texts was imported into MS Excel 2013. An suitable descriptive statistical analysis was used to characterize the data. In the event that the examination of the number rate did not reveal standard deviation or variance, heterogeneity between the studies was assessed using the Cochran Q test. The DerSimonian-Laird estimate for the I2 value was used in conjunction with the inverse variance approach. With Stats Direct Statistical Software Package (v3.35) and transformed data, the separate confidence intervals of the studies were calculated using the Clopper-Pearson technique.

For assessments of baseline (pre-treatment) with post-treatment values for various measurement parameters, meta-analysis was done utilising the random effects model. The Hedges g statistic, which is the difference between the two paired means divided by the pooled Standard deviation, was used to compute the standardized mean differences after accounting for small sample bias. The Standardized Mean Difference (MD) was deemed statistically significant at the 5% level (P0.05) if the value O did not fall within the 95% CI.

3. Result

A total of 953 documents were found after an electronic search of 4 databases—PubMed, Google Scholar, Cochrane, and Science Direct. After duplicates were eliminated, 907 articles underwent abstract screening. Following the screening, 888 papers were disqualified based on the titles and abstracts. In accordance with the qualifying requirements, 19 articles were chosen for full text evaluation. This systematic review contained 19 papers in total that met the predetermined inclusion criteria. In (Figure 1)

Author and year of publication, research design, duration of pain assessment, number of participants, age, kind of therapy, indirect variable, and result were all taken out of each study. The recommended reporting item for systematic review (PRISMA) standards were followed in the creation of this systematic review. The information from chosen papers had been gathered into organized tables by two calibrated reviewers (N.S. and R.R.).

Study design
Eight research (7, 9, 13, 22, 23, 24, 25, and 26) reported using a diode laser for disinfection in the irrigation procedure during endodontic re-treatment and treatment cases. There were a total of 19 investigations. The examination of the full-text did not include articles. The distinction among the control and test groups served as the basis for exclusion. Figure 1 depicts the selecting procedure we used for our investigation. The length of the research ranged from seven to nine months. The assessment of pain varied from 24 to 7 days. Participants in this research ranged in age from 18 to 79. The number of operators throughout the endodontic operation varied from one to four. With the exception of two research (9, 26), the majority of trials including endodontic treatment were completed in a single session. All studies employed patient-completed pain rating scales to assess postoperative pain.The use of analgesics following therapy was assessed as an outcome by two studies in 9,10,11,12,13.11,13 Table No. 1 contains a summary of all the studies' evaluations.

4. Methodological Assesment

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Table No. 2 provided a description of the laser administration protocol. The most popular kind was a diode laser(). Following treatment or retreatment, the laser was positioned intraorally at the level of the apices, at a modest distance from the tissue. The energy ranged from 3 J/cm2 to 90 J/cm2, the wavelength from 640 to 970 nanometers, and the power from 0.10 to 50 mW. The time frame was 25 s to 5 min. In the majority of trials, the laser regimen was only used once, just after the endodontic treatment.

Six research utilized a 10 cm VAS to measure pain severity, while two studies employed a numerical rating scale (NRS). Post-endodontic pain considerably decreased in the LLLT group at 4, 8, 12, 24 and 48 h following endodontic treatment, according to Anchal et al. and Ozgur et al. (P 0.05). At 12, 24 and 48 hours, Franciely et al. and Hakan et al. found a substantial pain decrease in the LLLT groups (P = 0.01). It was possible to undertake a meta-analysis, which is merely a qualitative study of the research, since there was less variation in the methods across the included studies, such as the identical wavelength, power, duration, frequency, and placement of the laser.

Forest plot was made for all the studies excluding the study by Dina et al, Tuna et al, Ezgi et al, Vijay et al. since heterogeneity was more than 50% random effect model was used.4,10,13 Meta-analysis revealed overall success rate of standard mean difference of -2.23 to -0.23 i.e. -1.24(95% CI) favoring the experimental group. Heterogeneity was present amongst the included studies. It was found to be 82% (P= 0.01) at 95% CI Forest plot was made for all the studies excluding the study by Dina et al, Tuna et al, Ezgi et al, Vijay et al. Since heterogeneity was more than 50% random effect model was used.4,10,13 Meta-analysis revealed overall success rate of standard mean difference of 11.44 TO 12.54 i.e. 0.55 (95% CI) NOT favoring the experimental group hence the standard mean difference was not conclusive. Heterogeneity was present amongst the included studies. It was found to be 100% (P<0.00001) at 95% CI.

Forest plot was made for all the studies excluding the study by Anchal et al, Dina et al, Tuna et al, Ezgi et al, Vijay et al.4,7,10,13 since heterogeneity was more than 50% random effect model was used. Meta-analysis revealed overall success rate of standard mean difference of -1.86 to 0.55 i.e. -0.65 (95% CI) NOT favoring the experimental group hence the standard mean difference was not conclusive Heterogeneity was present amongst the included studies. It was found to be 72% . Forest plot was made for all the studies excluding the study by Anchal et al, Dina et al, Tuna et al, Ezgi et al, Vijay et al. since heterogeneity was less than 50% fixed effect model was used.4,7,10,13 Meta-analysis revealed overall success rate of standard mean difference of -0.50 (95% -0.84 to - 0.16) favoring the experimental group. Heterogeneity was not present amongst the included studies. It was found to be 0% (P= 0.82) at 95% CI.

5. Result Of Meta Analysis

Statistical Report of day 1

Since the overall average tactical diamond is towards lies on the left side of the null effect which means it favors the experimental group. The pooled average difference between the experimental group and control group was estimated to be -1.24mm 95% CI (-2.23 to -0.25) (Plot-1) for estimation of post operative pain within 24 hrs. .

Statistical Report of day 2

Since the average stastical diamond is at the line of null effect not favoring control and experimental group which makes it non conclusive. The pooled average difference between the test group and control group was estimated to be 0.55 where CI is 95% (-11.44 to 12.54)(Plot-2) showing no post operative pain in both diode laser and mock laser group.

Statistical Report of day 3

The mean variation between the control group and the experimental group is greater because the average stastical diamond is in favor of the experimental group. With a 95% confidence interval of (-1.86 to -0.55), the calculated pooled average distinction among the test group as well as the control group is -0.65. (Plot-3) .The experimental group performs better on Day 3 of the post-operative pain evaluation.

Statistical Report of day 7

The mean variation between the control group and the experimental group is greater because the average stastical diamond is in favor of the experimental group. The calculated 95% confidence interval (CI) for the pooled average distinction between the groups that were tested and control group is (-0.84 to -0.16), or 0.-0.50. (Plot-4) The experimental group performs better on day 7 of the pain evaluation.

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Funnel plot:
A visual technique for spotting bias in meta-analysis is a funnel plot.
Only studies with equivalent outcome measures and comparable observation durations were used in the meta-analyses. A qualitative description was provided if a meta-analysis couldn't provide any results due to the measures' methodological heterogeneity.

Risk of bias assessment
The assessment of the danger of bias is shown in (Figure 5). Studies provide a comprehensive understanding of the randomization process. Trials that dealt with allocation concealment had a low risk of bias because they addressed the technique for concealing the allocation in a transparent manner. Not all of the papers highlighted incomplete outcome data, and we never got a response to our letters asking for risk explanation.

6. Discussion

Even after the inflammatory source has been eliminated by cleaning and shaping processes, varying degrees of pain and suffering may still exist, thus it was important to look into other pain treatment techniques because medications have a lot of unfavorable side effects 14.

Different laser kinds have been created over time and are employed in many dental specialties. Diode lasers are among the most widely utilized lasers out of all of them15. An indium, gallium, and arsenide-based solid-state semiconductor serves as the 980 nm diode laser's active medium. Diode lasers provide a number of benefits, including their great compactness, low cost, simplicity of setup, ease of use, and versatility16. Diode wavelengths are only weakly absorbed by tooth hard tissue but are heavily absorbed by hemoglobin and melanin. Water absorbs them very well as well, giving the laser the benefit of working accurately and selectively16.

The 980 nm diode laser delivers the beam to the target location across a 200 m optical flexible cable, likely dispersing the light evenly throughout the root canal for a more effective photoreaction15.

By modifying the bacterial cell wall, diode laser radiation exerts bactericidal effects. Microbiologists often discuss the irreversible breakdown of the cell membrane in connection with the effects of direct heat on bacteria. The bacteria are subjected to a photo-thermal action by the diode laser. Additionally, it has a photo-disruptive impact on bacteria that are out of reach.17 Diode laser light has been shown by Guteknecht et al.18 to reach a depth of >1000 m in the dentin. As a result, it may be a useful method for disinfecting the root canal system when used in conjunction with traditional biomechanical instruments to reach previously unreachable locations. When Garcez et al.19 employed optical fiber to disinfect the root canal, they saw a greater antibacterial impact. Diode lasers are shown to offer great clinical advantages.

The research by Dina et al.4 found that at all examined time points—6, 12, 24, 48, and 7 days—the diode laser group experienced statistically significantly less pain than the Endo group. These outcomes are consistent with those of Berk et al.20 and Pawar et al.21, who found that using a diode laser for root canal irradiation resulted in considerably less pain at 8, 24, 48, and 7 days after surgery compared to standard care.

When the healing process begins after a traditional RCT of chronic cases, as it did in the Dina et al trial4, the case often becomes acute, putting patients at risk for postoperative discomfort, which was not the case in the diode laser group, according to Tuner et al.22. It is still unclear exactly how using a laser causes post-operative pain to decrease. According to several writers, the diode laser can reduce pain through the following ways: By reducing PGE2, bradykinin, histamine, acetyl choline, and serotonin as well as the formation of substance P, Pawar et al.21 and Bjordal et al.6 discovered that the diode laser works on chronic pain and exhibits an anti-inflammatory impact.

The primary attribute of a randomized control clinical study is randomization. When this procedure is carried out properly, each participant is given an equitable assignment to the therapy. To know the group to which the patients will be allocated to, the study also needs allocation concealment. Four studies that were part of the systematic review undertaken by Dina et al. in 2018, Ezgi et al. in 2018, Tuna et al. in 2021, and Vijay et al. in 2021 lacked information about randomization.4,10,13

The outcome of the next crucial domain, blinding, may be affected by participant interreference. As the practitioner cannot be masked for laser therapy in the considered research, this solely applied to the patient. The

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laser point was triggered in the laser group yet not in the mock laser groups, and it was positioned at a modest distance from the tissue.23
In the research done by Dina et al. and Franciekly et al., the evaluators were blinded since they were the patients themselves because they documented their pain experiences on the rating scale.4,11 Two rating measures, the VAS and NRS, were applied to the patients' assessments of pain severity. The VAS scale is a continuous rating system made up of two verbal descriptions, one for each extreme of pain, that are spaced out along a vertical or horizontal line that is typically 10 cm long. Like VAS, NRS is a numerical scale.24

Inhibiting the production of inflammatory substances, reducing C fiber activity, and having regenerative effects are all results of diode laser treatment. However, scientific proof is still needed to determine how Diode laser treatment affects the penetration of tissues depths in endodontics. The primary determinant of penetration depth is the laser wavelength. It is important to note that the laser delivery schedule for all included investigations was essentially the same. Although there isn't a single wavelength that is acceptable worldwide, diode laser in dentistry is most frequently employed in the 600–1000 nm range. Although it cannot be completely ruled out that some wavelengths may be more successful than others in particular cell types, a thorough study conducted by Bjordal in 2006 found that wavelength variations had no detrimental effects on the outcome. The articles in this review varied in wavelength from 600 to 970 nm.6,25 Diode laser can counteract the negative effects of high inflammatory cytokine concentrations on gingival fibroblast activities.

The research's disadvantage, on the other hand, is that the comparison groups' pain scores varied. Additionally, this study monitored pain evaluation in the 24 hours, 48 hours, 72 hours, and 7 days following treatment and retreatment. A week appears to be a late time for pain analysis. The presence of preoperative pain was not recorded in subsequent randomized control trial trials, despite the fact that this was the variable that was proven to have the greatest effect on post-endodontic pain. The majority of the listed studies did not provide this data.4,5 Furthermore, endodontic retreatment involves a series of complex processes, where the finding of diode laser to be used subsequently as routine chemo-mechanical procedure for disinfection can efficiently reduce pain and provide comfort to the patient after endodontic treatment and retreatment.

7. Conclusion

Within the limitations of the present study, Diode laser stimulation had a positive effect on post operative pain subsequent to routine chemo mechanical procedures after endodontic treatment. Meta-analysis also stated that minimum post operative pain was seen in patients in which diode laser was used for canal disinfection. Thus, due to the low number of studies, further randomized clinical trials are recommended to provide better understanding of responses to both therapies.

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Tables and figures:

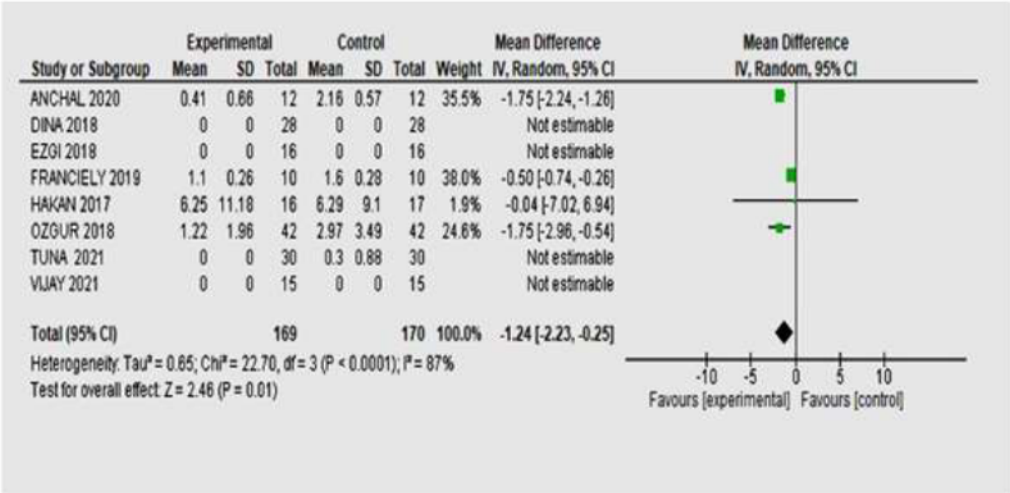

Figure no 1: DAY 1(24 HOURS) : TIME OF PAIN EVALUATION

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STUDY	SAMPLE SIZE	PROPORTION %	CI	WEIGHT (RANDOM)
Anchal 2020	24	90%	-2.24 to -1.26	35.55
Franciely 2019	20	100%	-0.74 TO -0.26	38 %
Hakan 2017	32	82%	-7.02 TO 6.94	1.9%
Ozgur 2018	84	78%	-2.96 TO -0.54	24.6%
TOTAL			-1.24	100%

Table 1: DAY 1(24 HOURS) : TIME OF PAIN EVALUATION

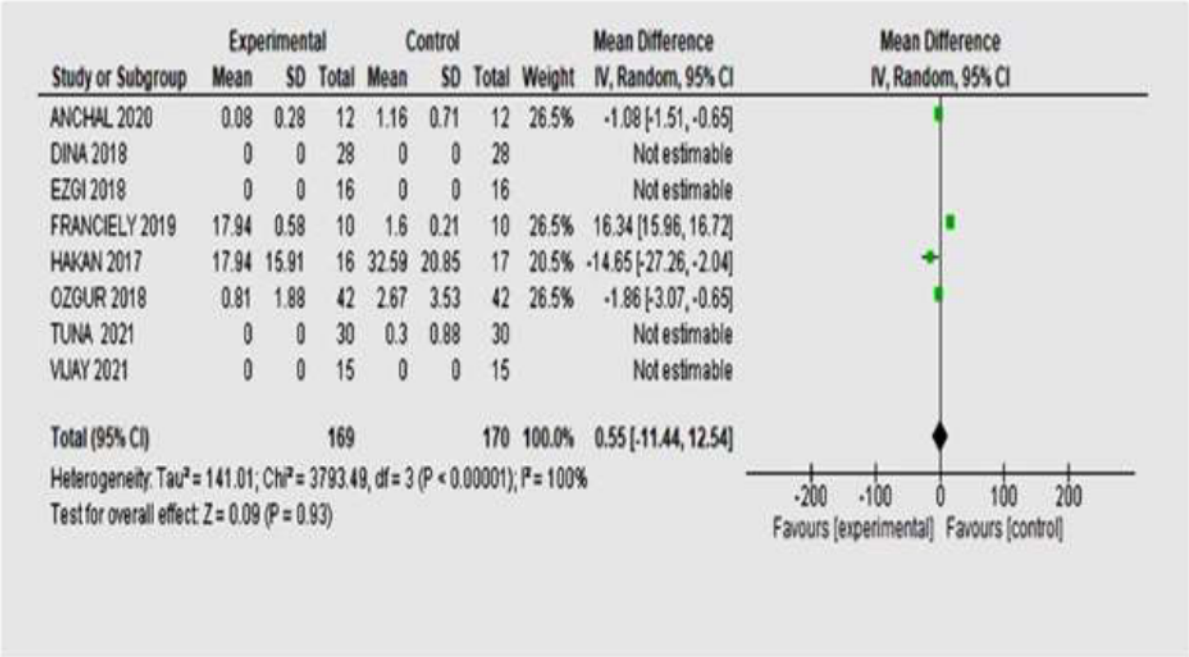

Figure 2: DAY 2(48 HOURS) : TIME OF PAIN EVALUATION

STUDY	SAMPLE SIZE	PROPORTION %	CI	WEIGHT (RANDOM)
Anchal 2020	24	90%	-1.51 TO -0.65	26.5%
Franciely 2019	20	100%	15.96 TO 16.72	26.5%
Hakan 2017	32	82%	-27.26 TO -2.04	20.5%
Ozgur 2018	84	78%	-3.07 TO -0.65	26.55
TOTAL			0.55(-11.22 TO 12.54	100%

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Table 2: DAY 2(48 HOURS) : TIME OF PAIN EVALUATION

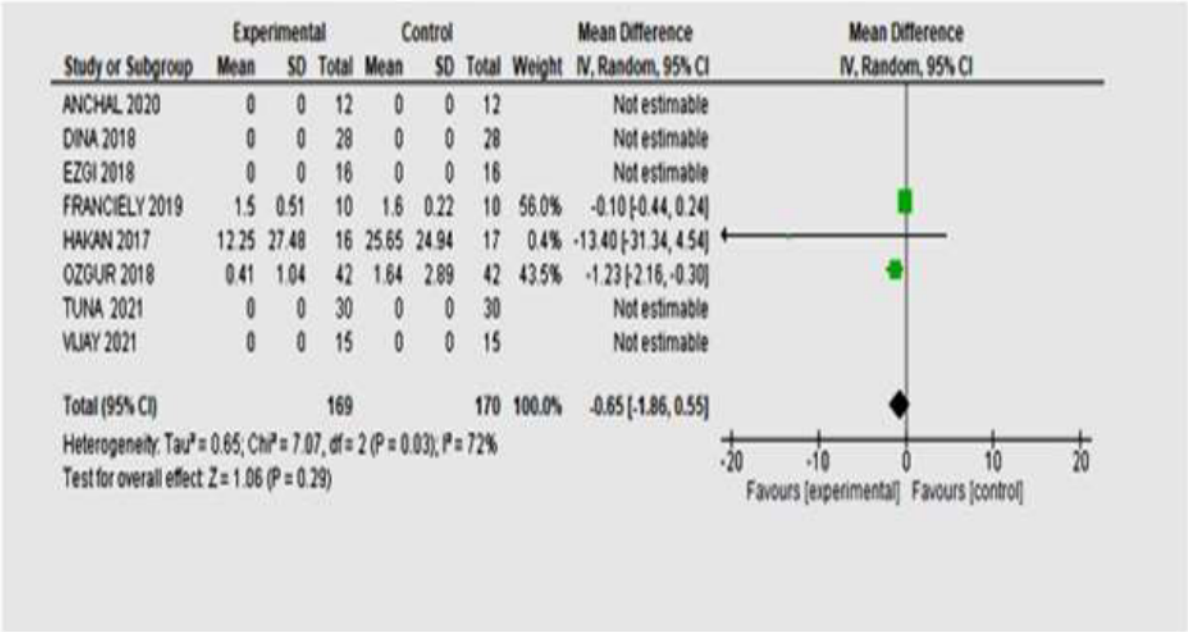

Figure 3: DAY 3(72 HOURS) : TIME OF PAIN EVALUATION

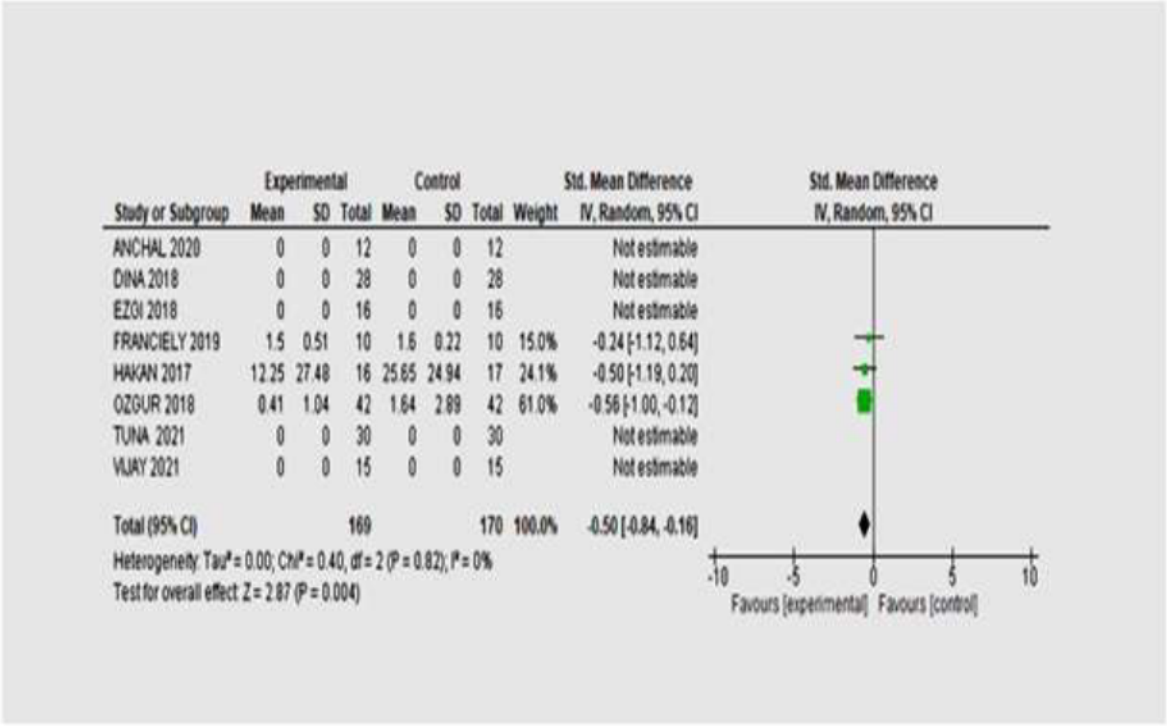

Figure 4: DAY 7: TIME OF PAIN EVALUATION

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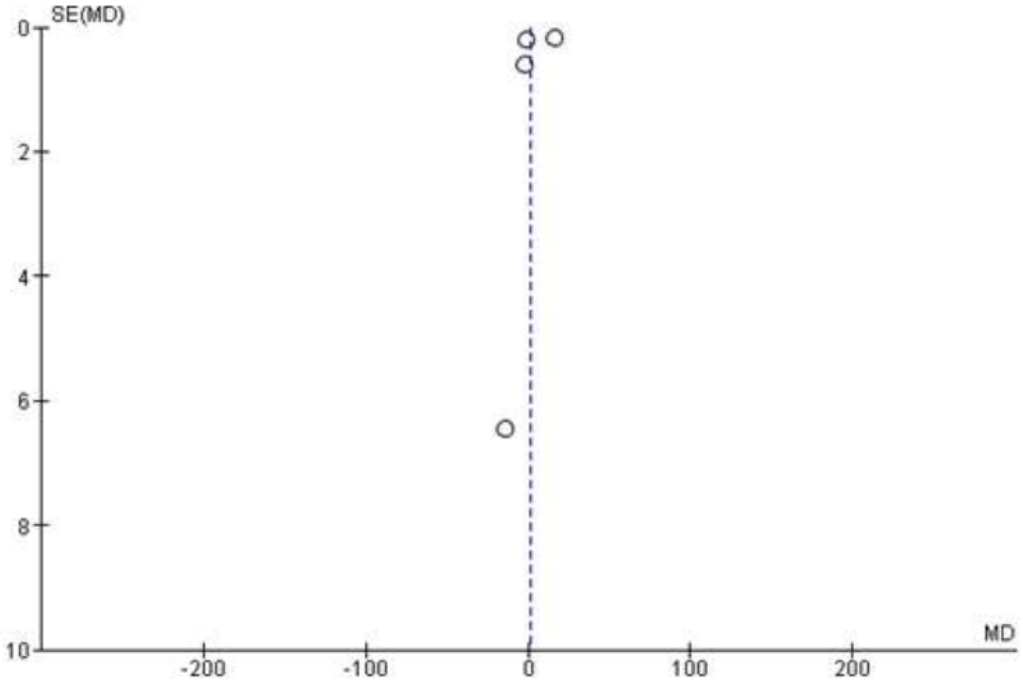
STUDY	SAMPLE SIZE	PROPORTION %	CI	WEIGHT (RANDOM)
Franciely 2019	20	100%	-1.12 to 0.64	15%
Hakan 2017	32	82%	-1.19 to 0.20	24.1%
Ozgur 2018	84	78%	-1.00 to -0.12	61%
TOTAL			-0.50 (-0.84 to -0.16)	100%

Table 3: DAY 7: TIME OF PAIN EVALUATION



EGGER'S TEST	
INTERCEPT	0.5567
95% CI	11. 44 TO 12.54
SIGNIFICANCE LEVEL	P<0.00001

Figure 5: Statistical Report – Funnel Plot (Day 2 of pain evaluation)

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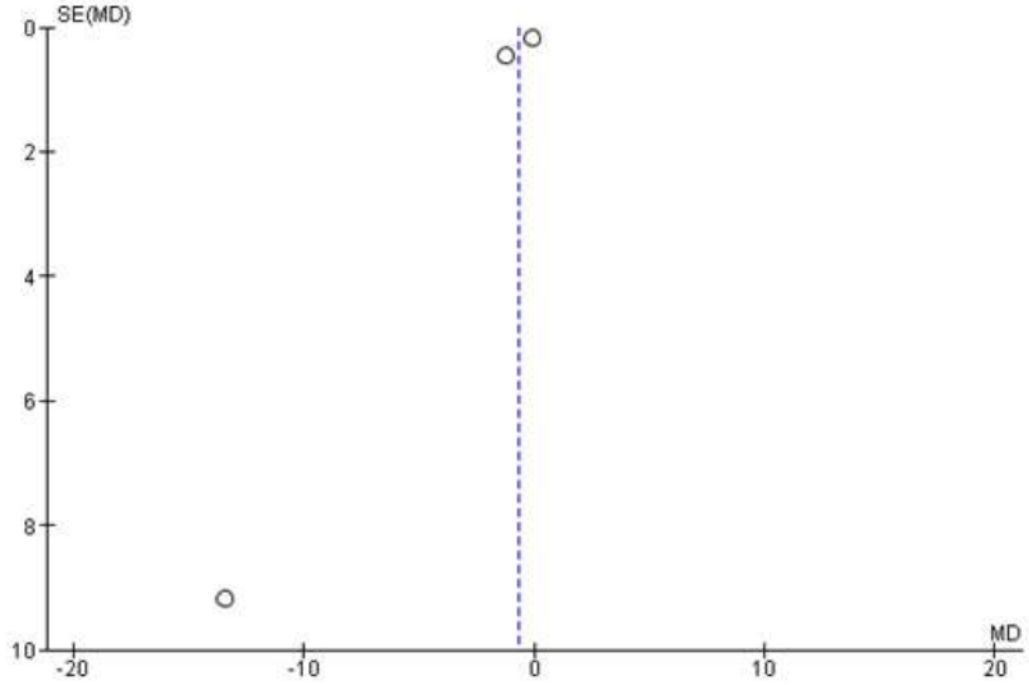
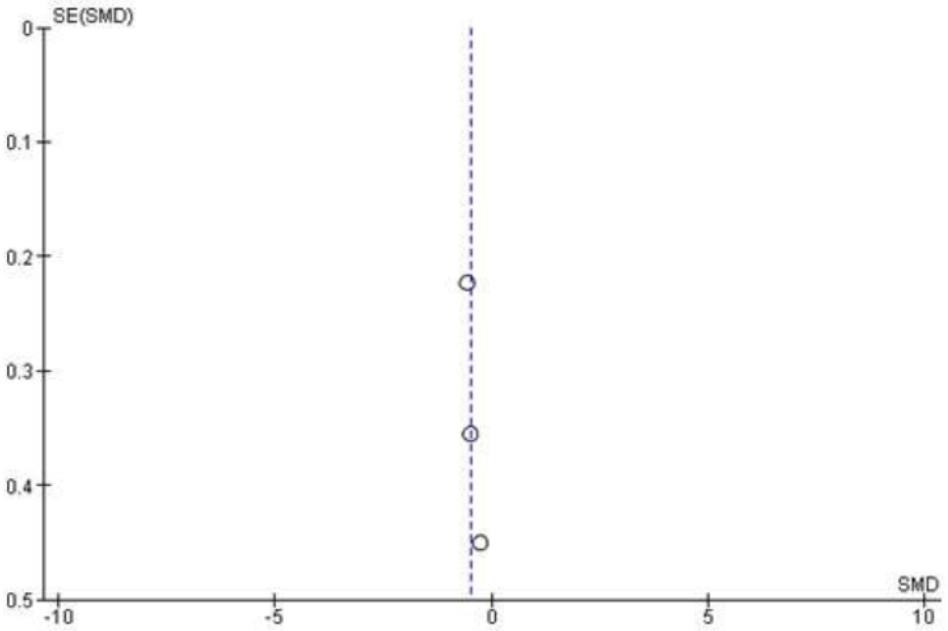


EGGER'S TEST	
INTERCEPT	0.6678
95% CI	-1.86 to 0.55
SIGNIFICANCE LEVEL	P=0.03

Figure 6: Statistical Report – Funnel Plot (Day 3 of pain evaluation)



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EGGER'S TEST	
INTERCEPT	0.40
95% CI	-0.50 (95% -0.84 to -0.16)
SIGNIFICANCE LEVEL	P=0.82

Figure 7: Statistical Report – Funnel Plot (Day 7 of pain evaluation)

Figure 8:
Cochrane risk-of-bias tool (RoB 2) (A) A review of the author's judgments about each risk of bias domain presented as percentages across the included studies. (B) A summary of the risk of bias in the included studies.

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