ORIGINAL ARTICLE

Effects of low-level laser therapy on orthodontic tooth movement: Evaluation of bone density changes via 3DCBCT

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ABSTRACT

Objective

Orthodontic treatment is known to cause tooth movement that is turn results in alteration in periodontal tissues including bone resorption. The impact will be enhanced withthe extended length of orthodontic treatment. Hence, the attempts are made to device an approach that can minimize the loss of periodontal tissue and promote bone regeneration. When it comes to orthodontic tooth movement (OTM), previous studies using Low-Level LaserTherapy (LLLT) have produced contradictory outcomes. This research uses cone beam computed tomography (3DCBCT) to compare bone density changes before and after orthodontic treatment in an effort to determine the effect of low-level laser therapy.

Research Tools and Procedures

Group A, the experimental group, had LLLT after orthodontic treatment at each appointment. Each application of diode laser had an overall energy was 75 J/tooth thatwas applied at five different locations for 3 seconds in the buccal /palatal region of maxillaryquadrant. On the other hand, control group (Group B) received only conventional orthodontics treatment. With the 3DCBCT, the gray values were measured for the interdental region (apical third) of the maxillary teeth ranging from right molar to left molar for both study groups before and after the intervention (LLLT). The gray values were presented in mean and standard deviation. The intergroup and intragroup comparisons were made with unpaired and paired ttest using SPSS v22.

Results and Discussion

In both the experimental and control groups, there was a non-significant ($P>0.05$) change between the pre- and post-laser intervention grey values representing bone density in the upper right quadrant (URQ), upper midline (UM), and upper left quadrant (ULQ). Similarly, when comparing the two groups within themselves, therewas no statistically significant difference ($P>0.05$) in the grey values.

Conclusion

Taking intoaccount the study's limitations, the results propose that LLLT does not significantly affect the changes in bone density associated with orthodontic tooth movement. Further investigation is necessary to determine the precise function of low-level laser therapy (LLLT) in tissueregeneration and its possible implications for clinical practice.

Keywords

Low-Level Laser Therapy, Bone density, Orthodontic treatment, Osteotomyogenesis, Cone Beam Computed Tomography

INTRODUCTION

Orthodontic tooth movement (OTM) occurs when mechanical stress is applied, causing the periodontal tissues to change biologically. Utilizing low forces is recommended to prevent bone necrosis or root resorption. This extends the length of orthodontic therapy. Prolonged treatment duration has negative consequences, including a higher occurrence of cavities, root resorption, and decreased patient compliance[1]. A kind of physical therapy known as low-level laser therapy (LLLT) has a stellar reputation for shortening treatment times [7,8]. This is mostly

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DOI: https://doi.org/10.3329/bjms.v24i10.79182

due to its low level of invasiveness and high level of safety [9]. The energy output of LLLT is low enough to keep temperatures below 36.5°C, the average body temperature of 10 people. A lot of recent studies have focused on how to use LLLT to speed up tooth movement[11]. Laser irradiation significantly speeds up tooth movement, according to previous animal and human studies . On the The fundamental principle of orthodontics is the repositioning of teeth by the use of orthodontic pressures[2]. When considering whether to undertake fixed orthodontic therapy, patients should prioritize avoiding protracted treatment durations to minimize the heightened risk of gingival inflammation and dental cavities[1]. Additionally, regular trips might be inconvenient[3]. flip side, many studies found that LLLT had no effect on OTM13 speed.

In a previous study[2,14,15], the authors used LLLT settings of 100 mW and 7.5 J/cm2, which produced promising outcomes for orthodontic patients regarding pain perception and root15 resorption. The Saudi population and the Various organizations have made efforts to discover methods for promoting bone remodelling in order to accelerate OTM[4,5]. These methods include the administration of medicines by local injection, application of physical stimulation, and corticotomy[6]. The use of injections and corticotomy in clinical practice is limited because to their unexpected systemic effects, as well as the local pain and discomfort they cause. Pakistani population [14] were the populations studied in these contexts, as was the migration of teeth. Before and after orthodontic treatment, computed tomography (CT) scans were used to assess bone abnormalities; no prior research has investigated the impact of LLLT on these changes. 3D cone beam computed tomography (3DCBCT) has recently made its way into dentistry clinics as a result of its increased affordability and smaller size [(16)]. Modern software may also create a three- dimensional model of the area, which helps the doctor visualise the target better. The current research on LLLT for OTC therapy involves laserdelivery either daily or at shorter intervals betweensessions.

On top of that, few studies have looked at how bone remodelling variables respond to LLLT and orthodontic force together. Using 3D cone beam computed tomography (3DCBCT), this research primarily intends to analyse how Low-Level LaserTherapy (LLLT) affects the orthodontic tooth movement process and to evaluate changes in bonedensity. The null hypothesis to be tested in the study was that, "There is no significant difference in bone density changes between orthodontic patients treated with Low-Level Laser Therapyand those treated without it".

MATERIALS AND METHODS

Ethics approval

With permission number 4-22-2/40, the Local Committee on Bioethics has given its stamp of approval to this research. By obtaining this permission, researchers may be confident theirstudy will be conducted in an ethical manner that will safeguard the participants' rights and well- being.

The main objective of this study is to examine howLow-Level Laser Therapy (LLLT) impacts the mobility of teeth in orthodontic treatment. 3D conebeam computed tomography (3DCBCT) evaluations of bone density variations will be the focus of this study.

Sample characteristics

Software for calculating power and sample size (version 3.1.2) was used to calculate the sample size. With a power of 0.80 and an alpha level of 0.05, the minimum needed sample size was determined using a predicted effect size from previous studies that were comparable. The research includes 32 participants, 16 men and 16 women, equally distributed across the sexes toaccount for any dropouts and provide enough statistical power. Age distribution will be presented, including mean and standard deviation.*Inclusion criteria*

- Patients aged 18-40 years.
- Patients with mild to moderate malignancies requiring dental care.
- Patients with generally good health status and no systemic diseases affecting bone metabolism.
- For patients with complex medicalhistories, there is no dental treatment.
- Patients with excellent oral hygiene and compliance with dental visits.

Exclusion criteria:

- Patients with severe systemic diseases affecting bone metabolism, such asosteoporosis or osteoporosis.
- Previous dental patients.
- Patients with scalp and facial pain requiring surgery.
- Patients with active arthritis or untreated dental caries.

- Patients with significant periodontal disease that may affect treatment outcome,such as missing teeth or major restorations.
- Pregnant or lactating women, due to possible hormonal effects on bone metabolism.
- Patients who are allergic or allergic to commonly used substances in dentistry.

Based on the aforementioned inclusion and exclusion criteria, the participants were randomized into two groups, designated as GroupA and Group B.

Experimental groups

The participants are divided into two main groups: Group A, designated for the experimental arminvolving LLLT, and Group B, serving as the control without LLLT intervention. Both groups share three common regions of interest: the Upper Right Quadrant (URQ), Upper Midline (UM), andUpper Left Quadrant (ULQ).

Upper Right Quadrant (Urq)

The Upper Right Quadrant (URQ) in dental anatomy corresponds to the upper-right region of the mouth cavity. This quadrant encompasses the amalgamation of teeth and their correspondingsupporting structures located on the right side of the upper dental arch. Regarding the investigationon Low-Level Laser Therapy (LLLT) and Orthodontic Tooth Movement, the URQ is a particular area of focus. The primary objective is to evaluate changes in bone density and tooth displacement within this specific quadrant,without explicitly indicating the numbers ofindividual teeth.

Upper Midline (Um)

The Upper Midline (UM) represents the precise midpoint of the upper dental arch. This entails an assessment of the teeth positioned in the middle of the dental arch, specifically focusing on the central incisors. The UM serves as a specified region for evaluating changes in bone density and tooth displacement, without expressly specifying the numbers of individual teeth.

Upper Left Quadrant (Ulq)

The Upper Left Quadrant (ULQ) specifically denotes the region located in the upper-left part ofthe oral cavity. It covers the teeth and the tissues that provide support on the left side of the upper dental arch. The ULQ, like the URQ and UM, primarily focuses on assessing changes in bone density and tooth displacement without explicitly identifying specific tooth numbers.

Intervention

A 100 mW stationary 940 nm Al-Ga-As diode laser (iLase; Biolase, Irvine, CA, USA) was the main component of the LLLT setup. The optical fibre had a tip diameter of 0.04 cm2. An energy density of 7.5 J/cm2 was present at each point, fora total of 75 J/tooth. At each appointment, LLLT was applied for three seconds to five differentspots on the gingival mucosa, beginning with the central incisors (#11 and #12) and continuing all the way to the first molars (#16 and #26). Not only were these five spots situated in the root's apical third, but they were also distal to the root and mesial to its cervical third and centre. The fibre tipof the laser was held perpendicular to the mucosa that protects the tooth roots while it delicatelytouched the gingival tissues.

Pre-Intervention and Post-Intervention assessments

A comparative evaluation of 3DCBCT grey values in the Maxillary quadrant is conducted before (Figure 1 A-D) and after (Figure 2 A-D) the LLLT intervention using NewTom cone beam 3D imaging along with NNT viewer. The 3D CBCT was working at 90 KV, 33.02mA, 5.6s, FOV – 10X10, and 0.15mm voxel size. This analysis aimsto capture any changes in bone density associated with Orthodontic Tooth Movement due to the application of Low-Level Laser Therapy.

operative assessment of bone density in #11 - #12 and #12 - #13 region respectively.

Common regions of interest

Participants in Group A have their Upper Right Quadrant (URQ), Upper Midline (UM), and UpperLeft Quadrant (ULQ) scrutinized. Tooth counts within the specified ranges for these regions are considered during the Pre-Intervention and Post- Intervention phases.

Study need:

It is crucial to use a longitudinal method thatcontrols for factors like patient age and health. Also, to make sure the research gives useful insights into the effectiveness of LLLT in orthodontic treatment, we'll compare the LLLT and control groups thoroughly to see whether theresults are statistically significant.

Statistical analysis

The study's demographics and the distribution of bone mass changes were summarised usingdescriptive statistics, such as standard deviation and mean, to

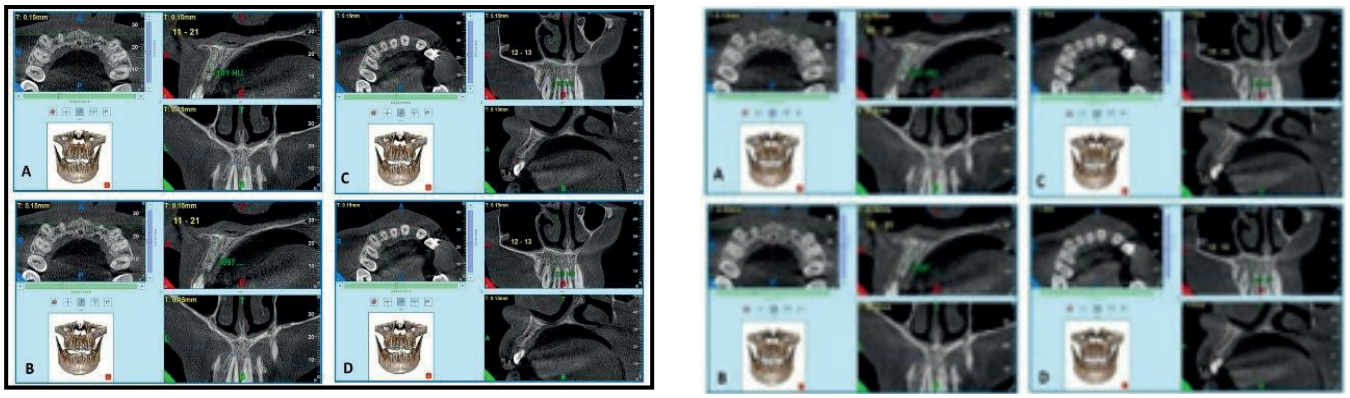

Figure 1 (A-D) – 3D CBCT scans in axial, sagittal,coronal planes of different maxillary regions of maxillary arch before and after the orthodontic treatment showing grey values in the interdental region. (A & C) Pre-operative and (B & D) Post

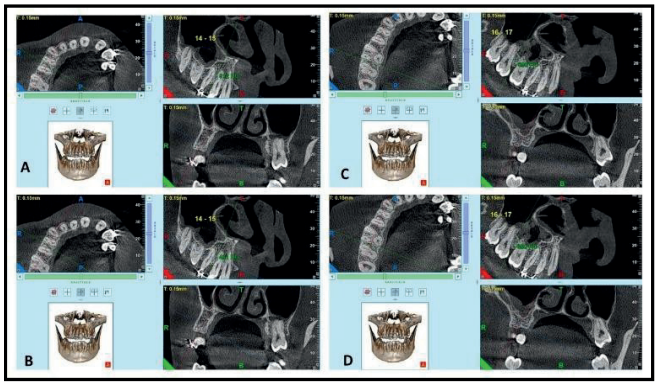

Figure 2 (A-D) – 3D CBCT scans in axial, sagittal,coronal planes of different maxillary regions of maxillary arch before and after the orthodontic treatment showing grey values in the interdental region. (A & C) Pre-operative and (B & D) Post operative assessment of bone density in #14 - #15and #16 - #17 region respectively.

describe the participants. To compare the changes in bone density between theexperimental and control groups, inferential statistics such independent t-tests were used. Forall statistical studies, SPSS version 25 was used.

RESULTS

Table 1 shows the study's sample criteria, contrasting the experimental group (Group A) withthe control group (Non-LLLT). Group A's mean age is 19.75 years with a standard deviation (SD) of 2.78, but Group B's mean age is 20.28 years with the same SD (p = 0.379). The gender distribution is balanced in both groups, with 16 men and 16 females making up 50% of each. The p-value is 1.00, which is considered non- significant. Based on these results, it can be concluded that the gender and age distributions of the experimental and control groups are similar. Table

Gender-n (%)	Female	16 (50)	16 (50)

Note: SD- Standard Deviation; LLLT - Low-Level Laser Therapy

1: Sample Characteristics

Variables		Group A (LLLT) / Experimental	Group B(Non-LLLT) / Control	P value
Age (Mean±SD)		19.75±2.78	20.28±2.78	0.379
	Male	16 (50)	16 (50)	1.00

Table 2 presents measurements (in micrometres) for orthodontic tooth movement in differentregions (URQ, UM, ULQ) and between specific tooth numbers (#) for both pre- and post-intervention in Group A (LLLT - Low-Level LaserTreatment). The P values indicate the statistical significance of the changes observed. For instance, in the URQ region, tooth movements (#17-#16 to #12-#11) show non-significant differences (P > 0.05), except for #13-#12 (P = 0.070). Similarly, in ULQ, movements between tooth numbers exhibit non-significant changes, except for #21-#22 (P = 0.103), #24-#25 (P = 0.110), and #25-#26 (P =

0.255). The UM region shows no significant difference overall (P = 0.56). These results provide a detailed analysis of tooth movement in responseto LLLT.

Table 2: Comparative evaluation of CBCT grey values of Maxillary quadrant before and after the treatment in Group A / Experimental study group

Region	Tooth Number (#)	Group A [LLLT]		P value
		Pre-Intervention n=16	Post-Intervention n=16	
URQ	#17-#16	660.59±122.71	660.38±122.99	0.051
	#16-#15	440.66±213.51	440.43±213.61	0.070
	#15-#14	481.87±195.17	481.69±195.20	0.056
	#14-#13	566.87±219.93	566.75±219.85	0.103
	#13-#12	748.06±277.17	747.84±277.17	0.070
	#12-#11	1016.47±108.12	1016.25±108.22	0.070
UM	#11-#21	1166.28±122.82	1166.09±122.80	0.56
ULQ	#21-#22	1159.06±117.99	1158.94±117.97	0.103
	#22-#23	1031.28±117.18	1031.16±117.23	0.255
	#23-#24	749.34±148.01	749.22±147.89	0.255
	#24-#25	701.09±192.84	700.91±192.78	0.110
	#25-#26	354.03±160.82	353.91±160.67	0.255
	#26-#27	494.81±213.31	494.72±213.36	0.476

Note: URQ - Upper right Quadrant; UM - Upper midline; ULQ - Upper left Quadrant; LLLT - Low-Level Laser Therapy

The table 3 presents a comparative assessment of grey values, measured in Hounsfield Units, in the maxillary quadrant before (Pre-Intervention) and after (post-intervention) treatment in Group B, which serves as the control study group. The regions examined include the Upper Right Quadrant (URQ), Upper Midline (UM), and Upper Left Quadrant (ULQ), with specific tooth numbers provided for each region. The grey values exhibit minimal changes in most cases, with P values indicating the statistical significance of the observed differences. Notably, tooth #12-#11 in the URQ shows a non-significant change, with Pre-Intervention values at 1011.22 ± 140.01 and post-intervention values at 1011.12 ± 140.08 (P = 0.374). Overall, this data suggests a relatively

Region	Tooth Number (#)	Group B (Non-LLLT)		P val ue
		Pre- Interventio n=16	Post- Interventio n=16	
URQ	#17-#16	665.96±135.72	665.81±135.79	0.096
	#16-#15	444.43±175.87	444.28±175.97	0.057
	#15-#14	468.91±158.07	468.81±158.03	0.083
	#14-#13	554.59±184.26	554.50±184.27	0.083
	#13-#12	737.81±265.96	737.72±265.99	0.184
	#12-#11	1011.22±140.01	1011.12±140.08	0.374
UM	#11-#21	1208.96±126.65	1208.88±126.62	0.184
ULQ	#21-#22	1203.66±160.62	1203.56±160.67	0.184
	#22-#23	1025.03±151.34	1024.63±151.54	0.119
	#23-#24	702.09±146.38	703.59±148.49	0.365
	#24-#25	734.09±145.23	734.03±145.35	0.423
	#25-#26	386.09±147.55	385.94±147.63	0.057
	#26-#27	520.13±186.15	520.03±186.03	0.184

stable grey value pattern in the maxillary quadrantafter the intervention in Group B.

Table 3: Comparative evaluation of grey values ofMaxillary quadrant before and after the treatment in Group B / control study group

Reg Oiorigin	Tootnhal Number	Pre-Intervention		P value	Post-Intervention		P value
		Researc Group A	h Group B		Group A	Group B	
URQ	#17-#16	660.59±122.71	665.96±135.72	0.869	660.38±122.99	665.81±135.79	0.867
	#16-#15	440.66±213.51	444.43±175.87	0.939	440.43±213.61	444.28±175.97	0.938
	#15-#14	481.87±195.17	468.91±158.07	0.771	481.69±195.20	468.81±158.03	0.773
	#14-#13	566.87±219.93	554.59±184.26	0.809	566.75±219.85	554.50±184.27	0.810
	#13-#12	748.06±277.17	737.81±265.96	0.881	747.84±277.17	737.72±265.99	0.882
	#12-#11	1016.47±108.12	1011.22±140.01	0.867	1016.25±108.22	1011.12±140.08	0.870
UM	#11-#21	1166.28±122.82	1208.96±126.65	0.176	1166.09±122.80	1208.88±126.62	0.175
ULQ	#21-#22	1159.06±117.99	1203.66±160.62	0.210	1158.94±117.97	1203.56±160.67	0.211
	#2	1031.	1031.	0.	1025.	1024.	0.

Note: URQ - Upper right Quadrant; UM - Upper midline; ULQ - Upper left Quadrant; LLLT - Low-Level Laser Therapy

The table 4 displays a comparative analysis of pre-intervention and post-intervention Cone Beam Computed Tomography (3DCBCT) grey values for various tooth regions and numbers in two groups, Group A and Group B. Mean pre- intervention grey values for tooth numbers in the Upper Right Quadrant (URQ), Upper

Middle (UM), and Upper Left Quadrant (ULQ) range from 354.03 to 1166.28, with corresponding P values indicating no significant differences between the groups ($P > 0.05$). Post-intervention grey values exhibit a similar trend, ranging from

353.91 to 1208.96, with P values remaining non-significant ($P > 0.05$). Overall, the data suggests that the intervention did not induce significant changes in 3DCBCT grey values between Group A and Group B across the evaluated tooth regionsand numbers.

Table 4: Intergroup Comparative analysis of Pre-intervention and Post-interventionCBCT grey values

Reg Oiorigin	Toot nal Number h	Pre- Intervention		P value	Post- Intervention		Pvalue
		Research Group A	Group B		Group A	Group B	
URQ	#17-#16	660.59±122.71	665.96±135.72	0.869	660.38±122.99	665.81±135.79	0.867
	#16-#15	440.66±213.51	444.43±175.87	0.939	440.43±213.61	444.28±175.97	0.938
	#15-#14	481.87±195.17	468.91±158.07	0.771	481.69±195.20	468.81±158.03	0.773
	#14-#13	566.87±219.93	554.59±184.26	0.809	566.75±219.85	554.50±184.27	0.810
	#13-#12	748.06±277.17	737.81±265.96	0.881	747.84±277.17	737.72±265.99	0.882
	#12-#11	1016.47±108.12	1011.22±140.01	0.867	1016.25±108.22	1011.12±140.08	0.870
UM	#11-#21	1166.28±122.82	1208.96±126.65	0.176	1166.09±122.80	1208.88±126.62	0.175
ULQ	#21-#22	1159.06±117.99	1203.66±160.62	0.210	1158.94±117.97	1203.56±160.67	0.211
	#2	1031.	1031.	0.	1025.	1024.	0.

DISCUSSION

In this work, we used 3D cone beam computed tomography (3DCBCT) to look at how LLLT affected tooth mobility during orthodontic treatment. This research aimed to examine thechanges in bone density between a group that got low-level laser therapy (LLLT) and a control group in order to assess the potential benefits of LLLT in facilitating orthodontic treatment. Despite the fact that the data suggest that low-levellaser therapy (LLLT) intervention might lead to insignificant changes in bone density, it is crucial to assess these results in relation to the current literature and pinpoint areas that need more research.

The use of low-level laser therapy (LLLT) in orthodontics has been investigated by several researchers, leading to various findings[17]. conducted a systematic review in 2018 that gathered findings from ten different studies and concluded that low-level laser therapy (LLLT) can potentially boost tooth mobility and shorten the length of treatment. Nevertheless, the authors emphasized the importance of doing studies that are of high quality, well-controlled, and have bigger sample numbers to validate these findings. The findings of a different systematic review conducted by[18] in 2021 were comparable, underlining the inadequate and inconclusive evidence concerning the efficacy of low-level lasertherapy (LLLT) in orthodontic conditions.

These studies are consistent with the findings of our investigation, which discovered that the observed changes in bone density were not statistically significant across most dental areas. This could be related to several factors, such as thesize of the sample, differences in the treatment procedure, and individual patient reactions. Even though our research design included a control group, additional studies with larger sample sizes and longer follow-up periods are required to arriveat more conclusive results.

To rub salt in the wound, 3DCBCT-based bone density study was the main focus of the present work. Use of cone beam computed tomography (CBCT) in dental practices has grown in recent years[19]. Thanks to the

CBCT data20's three- dimensional insight, the teeth and jaws' diagnostic and treatment planning process were much improved. The effects of LLLT on IRW bone changes were examined in this paper using 3DCBCT photos. A large body of literature has shown that CBCT data may reliably provide 3D information of the structures and tissues around teeth after OTM[21,22]. Utilising CBCT data, Purmal et al. (2013)[23] and Poggio et al. (2006)[24] measured IRW at various levels. On the other hand, CBCT scans are superior than CT scans when it comes to measuring skeletal alterations. The thinking behind this is that CBCT saves money and puts patients at reduced risk of radiation[25].

The effects of low-level laser treatment (LLLT) may be better studied in future studies if they included more outcome measures. Clinical evaluations of tooth movement, root resorption, and degrees of discomfort reported by patients might be included in these parameters. Studying the underlying mechanisms that low-level laser therapy (LLLT) uses to affect bone remodelling processes may also provide light on the treatment'spotential therapeutic benefits.

It is essential to highlight that several studies have documented favourable results using low-level laser therapy (LLLT) in particular clinical settings. A study conducted by[26] discovered that administering low-level laser therapy (LLLT) after corticotomy operations showed promise in speeding the movement of teeth in orthodontic treatment. Similarly, a study conducted by[27] revealed that low-level laser therapy (LLLT) would help minimize anchoring loss during orthodontic treatment. According to these findings, low-level laser therapy (LLLT) may be utilized in specific applications in orthodontics.

Stable, functional, and aesthetically pleasing orthodontic therapy requires proper root position. Because roots are not clinically evident and are typically unrelated to esthetics and occlusion, crown position is typically given more attention during orthodontic treatment than root position[28–30]. Occlusal function, restorative therapy, and periodontal health are all impacted by root location[31–33]. In teeth with weak root angulation, crown alignment faults are frequently visible on radiographs. In addition, the American Board of Orthodontics (ABO) advises evaluating root parallelism and subtracts points if neighboring teeth's roots are not parallel to one another or come into touch with one another[34]. Although the ABO and other publications have acknowledged that panoramic radiographs may not adequately reflect root position, the ABO nevertheless recommends using them to check root alignment[35,36]. Recent studies from 2022 to 2024 have further explored the effects of low-level laser therapy (LLLT) in orthodontics, with mixed outcomes. A meta-analysis confirmed that LLLT can modestly accelerate tooth movement by enhancing bone remodeling, though the results remain inconsistent due to variations in laser parameters and treatment protocols. Studies using 3DCBCT revealed that while LLLT may impact bone density, most reported changes were not statistically significant, aligning with earlier findings[37,38]. Additionally, some trials highlighted LLLT's potential to reduce pain and improve the rate of dental alignment, especially in cases of mandibular decrowding[39,40]. However, the consensus continues to emphasize the need for larger, well-controlled clinical trials to establish more definitive conclusions about LLLT's effectiveness in orthodontics[41].

Limitations and future directions

Our research contributes to the ongoing analysis of the role that IT plays in orthodontics, as stated in the conclusion. It is necessary to do additional research with bigger sample sizes, longer follow- up periods, and a variety of end measures to conclusively evaluate the efficiency of the treatment even though the changes in bone density that were detected did not display statistical significance. In addition, there is the possibility that the implementation of low-level laser therapy (LLLT) in orthodontic treatment could be advanced by investigating the mechanisms that underlie it and its potential in particular clinical settings.

CONCLUSION

Our investigation delved into the impact of Low-Level Laser Therapy (LLLT) on orthodontic tooth movement and bone density changes via 3DCBCT, with 32 participants evenly split between genders. Group A, the Experimental group, underwent LLLT, while Group B served as the Non-LLLT Control. Analysis focused on three key regions, revealing intriguing variations in 3DCBCT grey values. Comparative evaluations pre- and post-intervention highlighted potential influences of LLLT on orthodontic dynamics and bone density changes. Intergroup Comparative analysis underscored the distinct effects of LLLT. While further research is imperative for validation, our study contributes to advancing orthodontic interventions, emphasizing the

significance of exploring innovative modalities for enhanced patient care.

"**Acknowledgement:** This research was funded by Prince Sattam bin Abdulaziz University, grant number PSAU/2023/03/24842.

Conflicting Interest: None Authors contributions:

A.A.A.; M.K.A.; and K.C.S. conceived the research idea; A.A.A.; M.K.A.; and K.C.S.

prepared the article; A.A.A.; M.K.A.; B.S.A.; and K.C.S. collected and tabulated the information; M.K.A.; B.S.A.; and K.C.S. carried out the bibliographic search; M.K.A. and K.C.S. interpreted the results statisticians; A.A.A.; and B.S.A. helped in the development of the discussion; and M.K.A. and K.C.S. carried out thecritical revision of the article. All authors approvedthe final version of the article.

Ethical Policy And Institutional Review Board Statement

This project is approved by the Local Committee on Bioethics of Jouf University with its approval number 4-22-2/40. This consent ensures that the research meets ethical guidelines and standards, and protects the rights and welfare of research participants.

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