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Comparative Evaluation of Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage Control between Micro-Osteoperforation and Low Level Laser Therapy : an in-vivo Study

Dr. Helly Yogeshbhai Mehta[1*], Dr. Romilkumar Shah[2]

[1*] *Part III Postgraduate Student K. M. Shah Dental College and Hospital,Sumandeep Vidyapeeth Deemed to be University,Waghodia, Vadodara, Gujarat, India- 391760*
[2] *Professor and PG GuideK. M. Shah Dental College and Hospital,Sumandeep Vidyapeeth Deemed to be University, Waghodia, Vadodara, Gujarat, India- 391760*

***Corresponding author:** Dr. Helly Yogeshbhai Mehta,*
**Part III Postgraduate Student, K. M. Shah Dental College and Hospital, Sumandeep Vidyapeeth Deemed to be University, Waghodia, Vadodara, Gujarat,* India- 391760

Abstract

Aim: To evaluate and compare the Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage control between Micro-Osteoperforation (MOP) and Low Level Laser Therapy (LLLT).
Material and Methods: Twenty-one Participants were selected and randomly divided into Group 1 (MOP Side) and Group 2 (LLLT Side). All participants had to undergo individual Canine Retraction. Participants underwent MOP on the one side and LLLT on the other side. Canines were individually retracted using closed coil NiTi (9 mm) springs at 150gms force. Study models were made at T_0, 28th day (T_1), 56th day (T_2) and 84th day (T_3). OPG was collected at T_0 & T_3. Different parameters like Amount of Canine Retraction, Canine Rotation, Anchorage Control and Root Parallelism were evaluated.
Results: Mean retraction of 4.45±0.52 mm is seen in MOP side and 4.62±0.71 mm on the LLLT side. No significant difference is found in Anchorage Control (p=0.68) and Root Parallelism (p=0.171) between both groups. Higher incidences of disto-palatal Canine Rotation are seen in MOP Group (0.36±0.57), but is statistically not significant (p=0.01).
Conclusion: There was statistically no significant difference found in rate of Canine Retraction, Root Parallelism, Anchorage Control and Canine Rotation between MOP and LLLT Groups.

Key words: Micro-Osteoperforation, Low Level Laser Therapy, Accelerated Orthodontics, Canine Retraction.

Introduction

Orthodontics is an area of expertise in dentistry dealing with the correction of malaligned teeth, rectification of smile and establishing various facial proportions in order to attain an esthetically pleasing and socially acceptable facial profile.
The fundamentals of Orthodontic Tooth Movement (OTM) include the effect of inducers, influencers and inhibitors on tooth movement. The production of numerous inflammatory mediators such as Cytokines,

Arachidonic Acid Metabolites, Colony Stimulating Factors (CSF), Growth Factors and Neurotransmitters leads to a modification in the microenvironment around the Periodontal Ligament (PDL) when orthodontic forces act on the teeth. The bone also changes as a response to these forces. The response of the periodontium to OTM vary with signals from inflammatory mediators as well as host factors like malocclusion, metabolism, maturity, variation in density and form of bone, etc.

Novel devices and modalities have made orthodontic intervention more competent over the last two decades. Much advancement has been made in material and type of arch wires, bracket design and treatment protocols, but not faster. Today, the modern orthodontist strives to fasten the Orthodontic Treatment while living up to the patient's increasing expectations. "How long will the treatment take to finish?" is the primary concern of every patient and parent, prior to starting orthodontic treatment. As traditional orthodontic treatment usually takes longer to finish, all patients do not agree to undergo treatment. Extensive orthodontic treatment duration can lead to risks of periodontal disease, dental caries, root resorption and thinning of patient's motivation.[1] Owing to this impatient and fast lifestyle there is an irresistible urge toward reducing orthodontic treatment time.[2] Accelerating the OTM not only shortens treatment duration and reduces risks (such as periodontal problems, root resorption, and open gingival embrasure spaces) but also helps in enhancing the envelope of tooth movement, differential tooth movement and most importantly improving post-treatment stability.[3]

Adapting to the growing needs, orthodontic practice has experienced a paradigm shift towards accelerating OTM. Methods to accelerate OTM can be categorized into: Biological / Pharmacological (Vitamin D, Prostaglandin, Interleukins, Parathyroid hormone, etc.), Physical / Biomechanical stimulation (Direct Electric Currents, Pulsed Electromagnetic Field, Static Magnetic Field, Resonance Vibration, Low Level Laser Therapy (LLLT)) and Surgical (Interseptal alveolar surgery, Corticotomy, Osteotomy, Piezoscision, Micro-Osteo Perforations (Alveocentesis), Minimally Invasive Rapid Orthodontics (MIRO) and Laser Assisted Flapless Corticotomy).[4]

The acceleration techniques can also be divided on the basis of their aggressiveness into invasive, minimally invasive and non-invasive approaches. Invasive category comprises all surgically derived regional accelerations like Periodontally Accelerated Osteogenic Orthodontics (PAOO), Dento-Alveolar & Periodontal Distraction. Minimally invasive methods are modified surgical procedures, from reflecting a flap to flapless techniques such as Piezoscision, Corticision, etc
Surgical procedures are invasive, and patient's consent and cooperation is essential. Inter-Septal Alveolar Surgery, Corticotomy, Piezoscision and Corticision are more invasive and costly because surgical cuts and osteotomies are required. Post-operative complications like pain, swelling, haematoma and patient discomfort has diminished its popularity. Surgical interventions within bone not only increases the levels of cytokines and chemokines around the tooth (which play an important role in the recruitment of osteoclasts precursor cells through RANK/RANKL pathway) but also aids in differentiation of precursor's cells into mature osteoclasts thus accelerating OTM.[5]

The techniques that accelerate OTM, produce direct wounds to the alveolar or basal bones by initiating a wound repair response that acts as a Regional Acceleratory Phenomenon (RAP), in turn fastening the remodeling process and accelerating the OTM.
Micro-Osteo Perforations (MOP's) were earlier popular by the term Alveocentesis, literally meaning drilling the bone. It's the least invasive of all the acceleratory surgical methods. Propel Orthodontics devised an appliance for creating MOP's: Propel-TM. Alternative to the expensive Propel-TM device, mini-implant driver and mini-implants have gained popularity in routine practice.[6] These create controlled mini wounds in the bone at the desired area to exaggerate the natural inflammatory response of the body. This heightens the chemokines and cytokine activity.[7] Chemokines increase osteoclast cell number while the cytokines increase the conversion of macrophages into osteoclasts via the RANK-RANKL (Receptor Activator of Nuclear factor Kappa-B Ligand) Pathway and the Prostaglandin E2 Pathway. The MOP Procedure has a few short lived complications: mild-moderate pain, discomfort & difficulty in chewing. But these don't last long.[8] Various uses of MOP include canine retraction, anterior crowding, molar distalization, expansion, Molar uprighting, Impacted canine, Forced eruption, to ease Difficult aligner OTM, Space closure, Rotations, Intrusion, Correction of Curve of Spee, etc.[9]

Different techniques for MOP have been used in different studies. It can be carried out under LA using Mini-implant. The mini-implant is screwed slowly through the alveolar mucosa into the alveolar bone in a

perpendicular angulation, until slight blanching is noticed in soft tissue surrounding the mini-implant to confirm full-length penetration, after which it is unscrewed and removed.[6]

MOPs can be achieved using a device called Propel, specially formulated to apply alveocentesis. The tip part is like an orthodontic mini-implant that permits perforation of alveolar bone. It helps initiatation of tissue remodeling and MOP's between tooth roots over both attached mucosa and movable tissue. A 1.5 mm diameter and varying depth of 3/5/7 mm without raising a flap.[10]
Advantages of MOP are that it is less invasive, is a flapless procedure with minimal to no patient discomfort.[11] The only disadvantage of MOP is the cost (though it is less than surgical procedures) and because the cytokine activity reduces after 8 weeks it has to repeated until desired results are attained.
Low Level Laser Therapy (LLLT) is a non-invasive procedure that accelerates OTM through its Bio-stimulatory effect on bone. The irradiation with Laser stimulates the proliferation of fibroblasts, Osteoblasts and the osteoclasts leading to increased bone turnover.[13] This results in increase in the production of ATP along with stimulation of cytochrome C38 and improving OTM by RANK/RANKL and the macrophage colony-stimulating factor (M-CSF).[14]
Orthodontic pain is a troublesome side effect and is one of the major concerns among patients. Uneasiness, dull pain, and hypersensitivity are inevitable, which can lead to incompliance or early treatment end.[15] Additional effects of LLLT other than accelerated OTM, are its painkilling and anti-inflammatory effects and anti-root resorption.[16,17,18]
In current scenario MOP and LLLT are gaining popularity due to comparatively low invasive nature, cost effectiveness and stimulatory effects on Orthodontic Tooth Movement with relatively low risks when compared to other techniques. Thus, the current study aims to compare and evaluate the rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage control between Micro-Osteoperforation (MOP) and Low Level Laser Therapy (LLLT).

Null Hypothesis

There is no difference between MOP and LLLT in terms of Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage control.

Aims and Objectives

Aim: To evaluate and compare the Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage control between Micro-Osteoperforation (MOP) and Low Level Laser Therapy (LLLT).

Objectives:

- ✓ To evaluate the Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage Control using MOP.
- ✓ To evaluate the Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage Control using LLLT.
- ✓ To compare Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage Control between MOP and LLLT.

Material and Methodology

Sample Description: Sample size was estimated using the following assumptions: Alpha error = 5%, beta error = 20%, reading in group 1= 0.94, reading in group 2= 1.21, common standard deviation = 0.31 according to the study conducted by Neda Babanouri et al.34The minimum required sample size was calculated to be 21. The minimum required sample size per group was thus set at 25. The Type I error = 5% and Type II error = 20% , meaning $1-\beta$ is power = 80%.
Time Scale of the Study: Study was started after obtaining SVIEC approval and completed within 24 months from the date of approval.
Selection Criteria:

- ❖ Inclusion Criteria:
  - Age between 18 to 30 years.
  - Bilateral Maxillary First Premolar extraction Case treated with Fixed Mechanotherapy [0.022" MBT

Preadjusted Edgwise Appliance]

- Periodontal probing depth less than 3mm across the entire dentition.
- Patients with well aligned upper anterior teeth.
- Patients who have average growth pattern.

❖ Exclusion Criteria:

- Patients having diseases and/or under medication which are likely to affect bone biology.
- Patients having radiographic evidence of bone loss.
- Patients having periodontal disease.
- Habit of smoking.
- Use of anti-inflammatory drugs during the month preceding the study.

The study was commenced in the Department of Orthodontics and Dentofacial Orthopaedics, K. M. Shah Dental College & Hospital, after receiving ethical approval from Sumandeep Vidyapeeth Institutional Ethical Committee (SVIEC). The patients were selected as per inclusion and exclusion criteria. The selected participants were introduced to the aims, objectives and methodology of the study with the help of participant information sheet. After the participant agreed to participate in the study, a signed written informed consent form was taken from them.

After Bilateral Extractions of indicated Maxillary first premolars, bonding was done using Fixed Mechanotherapy [0.022" MBT Preadjusted Edgewise Appliance]. After achieving initial Alignment and Leveling the Maxillary quadrants were randomly divided into right and left sides using Simple Random Sampling technique and were allocated to Group I - MOP (Micro-Osteoperforation) Side and Group II - LLLT (Low Level Laser Therapy) Side. Canine retraction was initiated on 0.019" × 0.025". SS wire with Ni-Ti closed coil spring (9 mm) exerting a force of 150 grams measured using Dontrix Gauge.8All the procedures were performed by the same operator for both the groups. All the participants were instructed to maintain Oral Hygiene meticulously by same type of orthodontic toothbrush and mouthwash as provided by the operator.

Group-I: Micro-Osteoperforations (MOP): For the MOP side, 3 MOPSs were done on the buccal cortical plate under local anesthesia. The patients were asked to rinse their mouth twice with chlorhexidine for 1 minute. Local anesthesia was then given (2% Lidocaine with 1:100,000 Epinephrine). A MOP of 1.5 mm width and 3 mm depth inside the bone was made. MOPs were performed using Miniscrews of 1.5 mm diameter and 6 mm length. The points of screw insertion were demarcated by bleeding points using a calibrated periodontal probe. One row consisting of 3 holes were made distal to the canine on an imaginary line passing from the centre of the extraction space. For standardization of the protocol, the exact location of screw insertion was determined as the following: the first MOP was made 4 mm from the free gingival margin. The second MOP was marked 2 mm from the first one. The third MOP was marked 2 mm from the second MOP

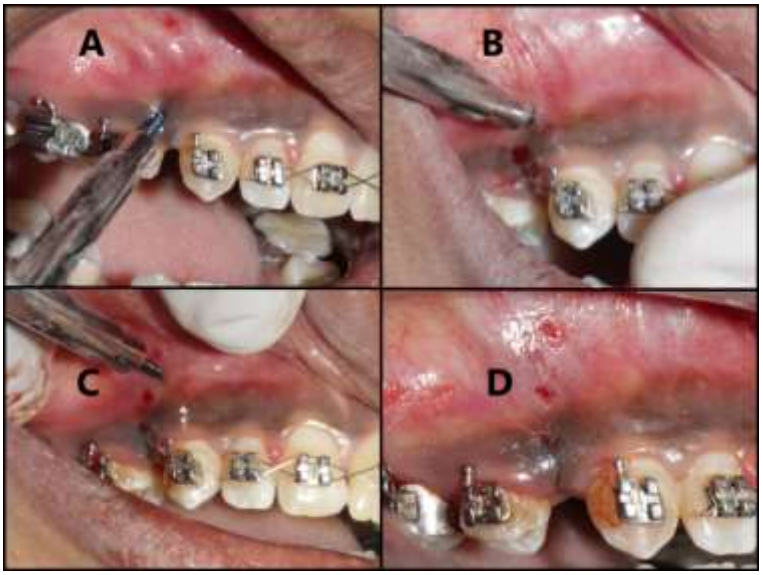


Figure-1 (A-D): Procedure of MOP. After infiltration with Local Anaesthetic first Micro-Osteoperforation is done 5mm gingival to the alveolar crest as shown in **A**. 2nd and 3rd Osteoperforation are done 3 mm from the prior perforation **B & C**.

Group -II: Low Level Laser Therapy (LLLT):
For the LLLT side, irradiations were delivered by applying the laser probe over 8 points per canine tooth (4 on the buccal side and 4 on the palatal side). The laser output was set at 10 seconds per point in continuous mode. LLLT was applied at initiation of canine retraction i.e. immediately after spring activation (T_0), on 28th day (T_1), and on 56th day (T_2) subsequently
Just before the start of Canine Retraction (T_0) the study models were prepared using Orthokal. Subsequent study models were made at 28th day (T_1), 56th day (T_2) and 84th day (T_3) for assessing and comparing the rate of Canine Retraction, Canine Rotation and Anchorage Control on both sides. The Orthopantomogram was recorded before start of canine retraction (T_0) and at T_3 for assessment of Root Parallelism between Canine and 1st Molar.

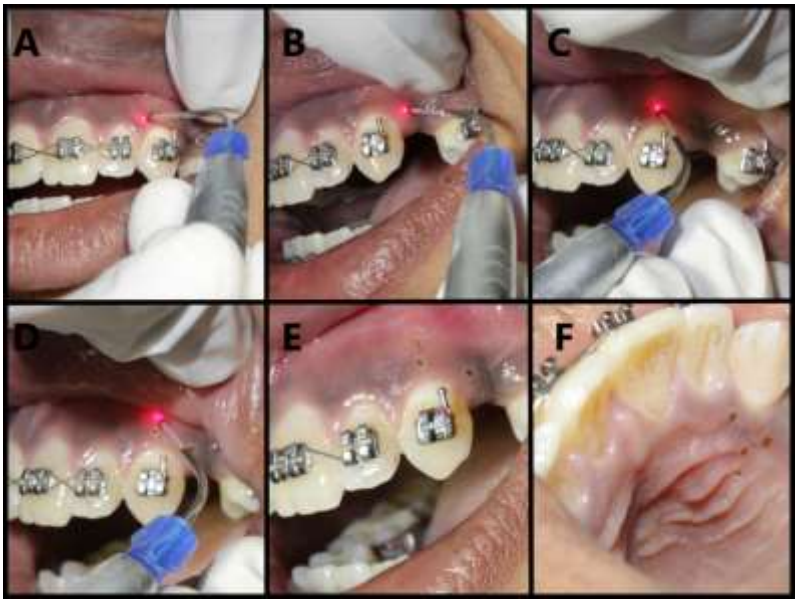


Figure-2 (A-F): Process of application of LLLT. A. Irradiation on the mesial aspect of Canine. **B.** Irradiation on the distal aspect of Canine. **C.** Irradiation on the deepest of the gingival Margin. **D.** Irradiation 2 mm above irradiation C**. E.** All 4 buccal irradiated spots. **F.** All 4 palatal irradiated spots.

Parameters under study:

I. **Assessment of rate of Canine Retraction:**
II. **Root Parallelism:**
III. **Canine Rotation:**
IV. **Anchorage Control:**

Observations and Results

Table 1: Demographic data

	Frequency	Percent (%)
Females	14	57.1
Males	11	42.9
Total	25	100.0

The data on both LLLT & MOP groups were evaluated under two main headings: intragroup comparison and intergroup comparison.

✓ **Intragroup Comparison**
The amount of Canine Retraction is statistically significant ($p<0.001$) at all-time intervals (T_0-T_1, T_1*T_2, T_2-T_3 & T_0-T_3) for both MOP and LLLT Groups (**Table-2, Table-3** & **Chart-2**). Root Parallelism between Canine and 1st Molar is not statistically significant in MOP Group between T_0 (6.57±4.33) and T_3 (8.43±3.99) ($p=0.024$) and LLLT Group between T_0 (6.67±4.26)and T_3 (8.67±3.98) ($p=0.025$) (**Table-4, Table-5, Chart-3** &**Chart-4**). Canine Rotation is statistically significant in MOP Group between T_0 (37.26±4.35) and T_3 (29.19±4.25) ($p<0.001$) and LLLT Group between T_0 (37.19±4.25)and T_3 (28.83±4.19) ($p<0.001$) (**Table-6, Table-7** &**Chart-5**). Anchorage Loss is statistically significant in MOP Group between T_0 (7.19±2.06) and T_3

(6.79±2.11) ($p<0.001$) and LLLT Group between T_0 (7.19±2.06)and T_3 (6.83±2.12) ($p<0.001$) (**Table-8, Table-9** &**Chart-6**).

Table-2: Paired t-tests to compare the amount of Canine Retraction achieved by MOP between all-time intervals.

MOP	Mean ± SD	Mean difference ± SD	t	p Value
T0	7.48±0.75	-1.86±0.28	-30.36	**<0.001**
T1	9.33±0.7			
T1	9.33±0.7	-1.31±0.25	-24.12	**<0.001**
T2	10.64±0.69			
T2	10.64±0.69	-1.29±0.25	-23.24	**<0.001**
T3	11.93±0.62			
T0	7.48±0.75	-4.45±0.52	-39.08	**<0.001**
T3	11.93±0.62			

Table-3: Paired t-tests to compare the amount of Canine Retraction achieved by LLLT between all-time intervals.

LLLT	Mean ± SD	Mean difference ± SD	t	p value
T0	7.48±0.75	-1.66±0.37	-20.47	**<0.001**
T1	9.13±0.72			
T1	9.13±0.72	-1.46±0.21	-31.63	**<0.001**
T2	10.59±0.78			
T2	10.59±0.78	-1.5±0.38	-18.33	**<0.001**
T3	12.1±0.86			
T0	7.48±0.75	-4.62±0.71	-30.01	**<0.001**
T3	12.1±0.86			

Chart-2: Comparison of Space between Canine and Lateral Incisor at all-time intervals for MOP & LLLT

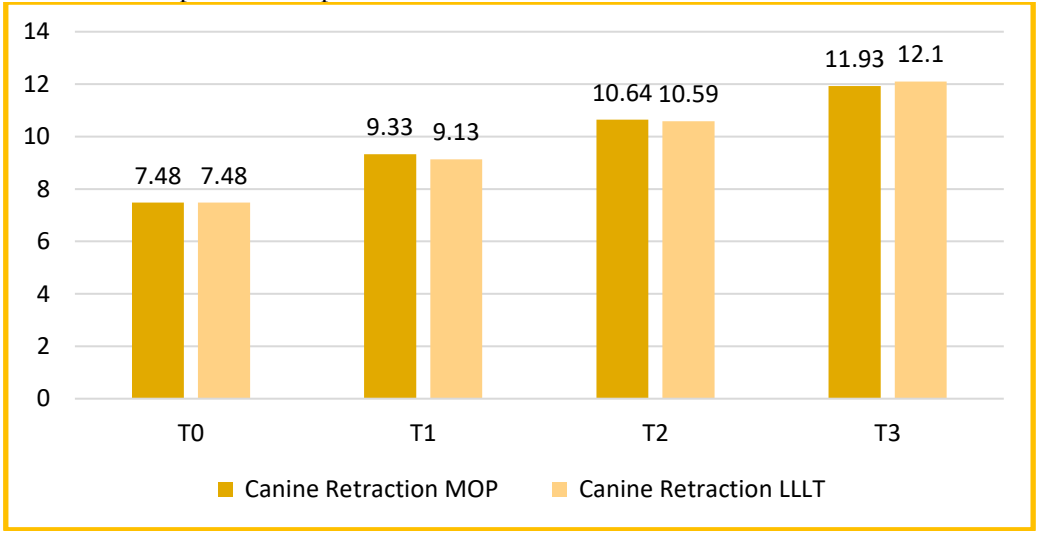


Table-4: Paired t-tests to compare the Root Parallelism achieved by MOP between all-time intervals.

MOP		Mean ± SD	Mean difference ± SD	t	p value
OP - C	T0	88.76±4.95	3.9±2.47	7.25	**<0.001**
	T3	84.86±4.07			
OP - 1st M	T0	94.86±4.3	0.71±3.45	0.95	0.354
	T3	94.14±3.98			
C – 1st M	T0	6.57±4.33	-1.86±3.48	-2.44	0.024
	T3	8.43±3.99			

Table-5: Paired t-tests to compare the Root Parallelism achieved by LLLT between all-time intervals.

LLLT		Mean ± SD	Mean difference ± SD	t	p value
OP - C	T0	88.71±4.94	3.81±2.5	6.98	**<0.001**
	T3	84.9±4			
OP - 1st M	T0	95±4.25	0.57±3.6	0.73	0.475
	T3	94.43±4.27			
C – 1st M	T0	6.67±4.26	-2±3.79	-2.42	0.025
	T3	8.67±3.98			

Chart-3: Measure of Root Parallelism on the MOP side

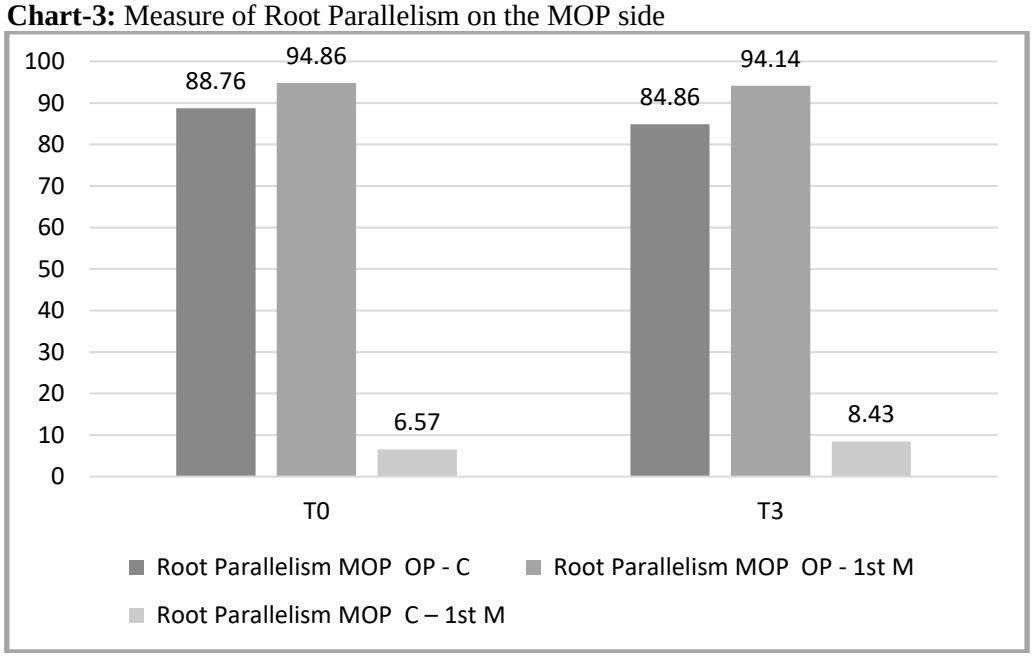


Chart-4: Measure of Root Parallelism on the LLLT side

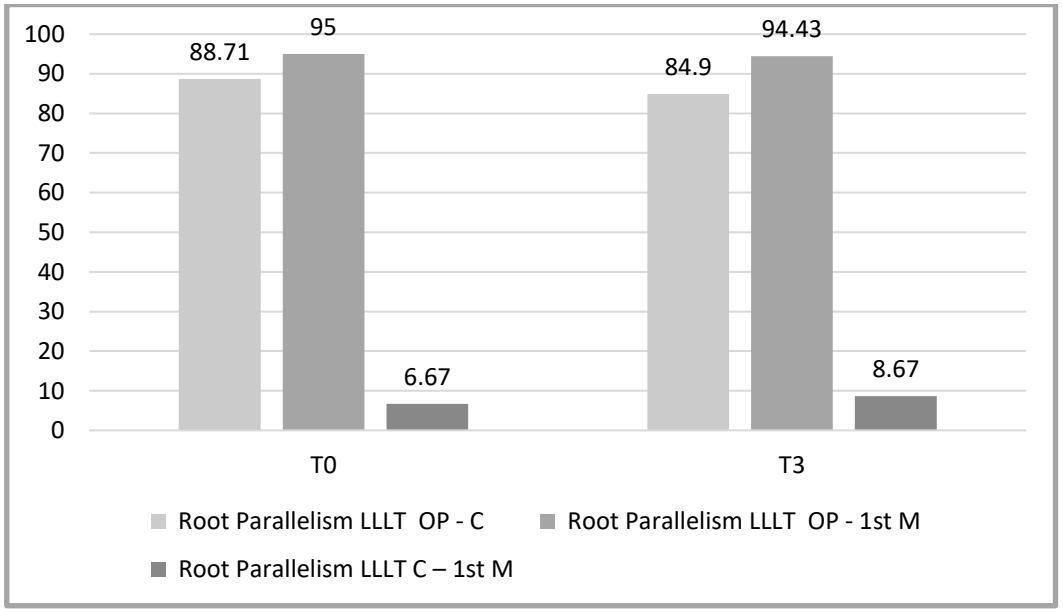


Table-6: Paired t-tests to compare the Canine Rotation occurring by MOP between T0 & T3

	Mean ± SD	Mean difference ± SD	t	p value
T0	37.26±4.35	8.07±0.1	65.54	**<0.001**
T3	29.19±4.25			

Table-7: Paired t-tests to compare the Canine Rotation occurring by LLLT between T0 & T3

	Mean ± SD	Mean difference ± SD	t	p value
T0	37.19±4.25	8.36±0.57	66.81	**<0.001**
T3	28.83±4.19			

Chart-5: Measure of Canine Rotation occurring by both MOP & LLLT at T0 & T3

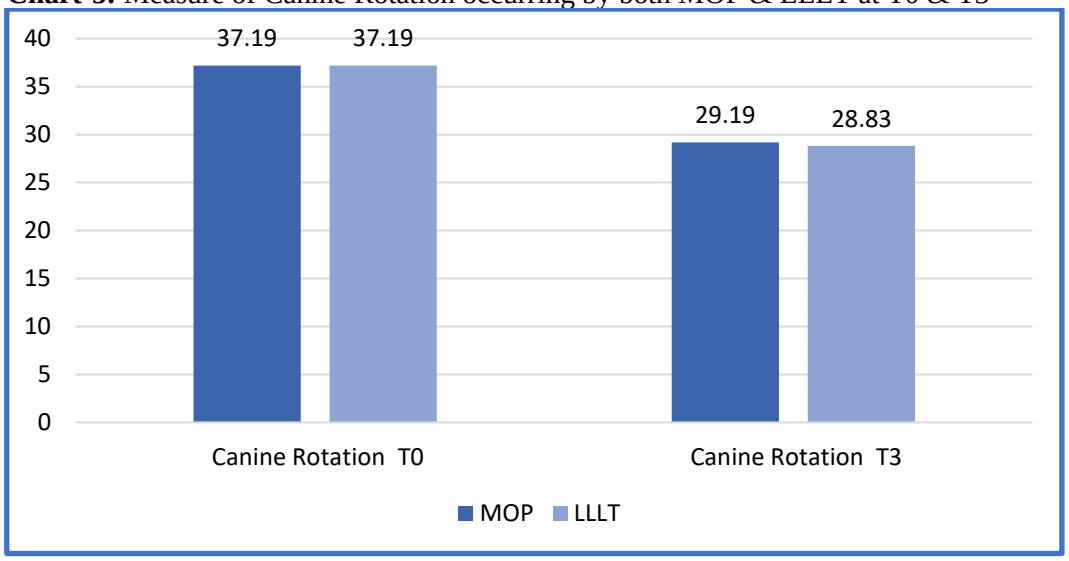


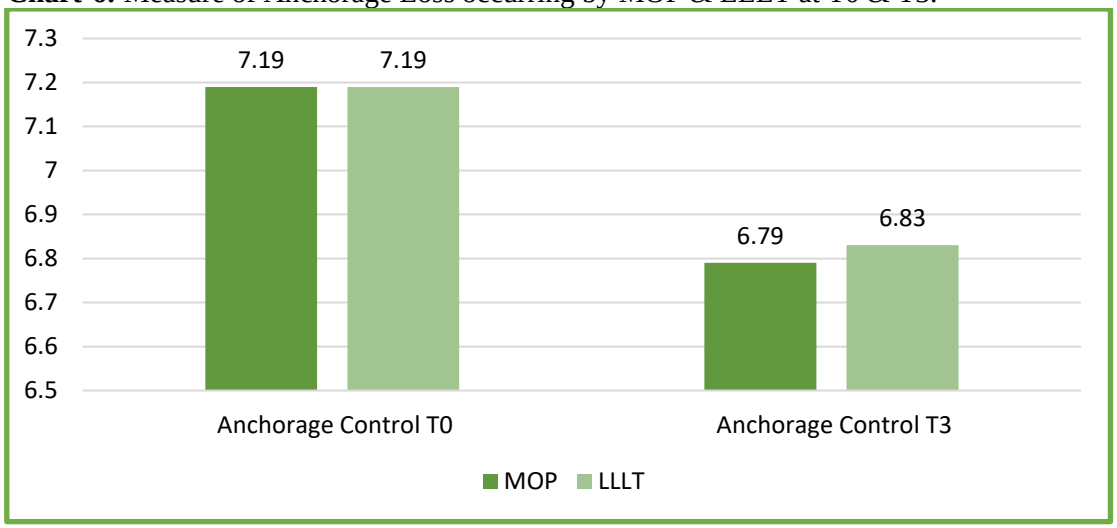
Table-8: Paired t-tests to compare the Anchorage Loss occurring by MOP between T0 and T3

	Mean ± SD	Mean difference ± SD	t	p value
T0	7.19±2.06	0.4±0.41	4.56	**<0.001**
T3	6.79±2.11			

Table-9: Paired t-tests to compare the Anchorage Loss occurring by LLLT between T0 & T3

	Mean ± SD	Mean difference ± SD	t	p value
T0	7.19±2.06	0.36±0.39	4.18	**<0.001**
T3	6.83±2.12			

Chart-6: Measure of Anchorage Loss occurring by MOP & LLLT at T0 & T3.



✓ **Intergroup Comparison**

On comparing the Amount of Canine Retraction achieved at T_3 between MOP (4.45±0.052) and LLLT (4.62±0.7), no statistically significant difference was found (p=0.297) (**Table-10** &**Chart-7**). On comparing the Root Parallelism between Canine and 1st Molar at T_3 between MOP (8.43±3.99) and LLLT (8.67±3.98), there was no statistically significant difference (p=0.171) (**Table-11**). On comparing the Canine Rotation at T_3 between MOP (29.19±4.25) and LLLT (28.83±4.19), there was no statistically significant difference found

(p=0.01) (**Table-12**). On comparing the Anchorage Loss at T_3 between MOP (6.79±2.11) and LLLT (6.83±2.12), there was no statistically significant difference found (p=0.68) (**Table-13**).

Table-10: Intergroup Difference in the amount of Canine Retraction in between MOP & LLLT at all-time intervals.

		Mean ± SD	Mean difference ± SD	t	p value
T1-T0	MOP	1.86±0.28	0.2±0.28	3.26	**0.004**
	LLLT	1.66±0.37			
T2-T1	MOP	1.31±0.25	-0.15±0.37	-1.82	0.084
	LLLT	1.46±0.21			
T3-T2	MOP	1.29±0.25	-0.22±0.37	-2.75	0.012
	LLLT	1.5±0.38			
T3- T0	MOP	4.45±0.52	-0.17±0.71	-1.07	0.297
	LLLT	4.62±0.71			

Table-11: Intergroup Difference between different measures of Root Parallelism in MOP & LLLT

Time			Mean ± SD	Mean difference ± SD	t	p value
T0	OP - C	MOP	88.76±4.95	0.05 ± 0.22	1.00	0.329
		LLLT	88.71±4.94			
	OP - 1st M	MOP	94.86±4.3	-0.14 ± 0.48	-1.37	0.186
		LLLT	95±4.25			
	C – 1st M	MOP	6.57±4.33	-0.1 ± 0.54	-0.81	0.428
		LLLT	6.67±4.26			
T3	OP - C	MOP	84.86±4.07	-0.05 ± 0.22	-1.00	0.329
		LLLT	84.9±4			
	OP - 1st M	MOP	94.14±3.98	-0.29 ± 0.72	-1.83	0.083
		LLLT	94.43±4.27			
	C – 1st M	MOP	8.43±3.99	-0.24 ± 0.77	-1.42	0.171
		LLLT	8.67±3.98			

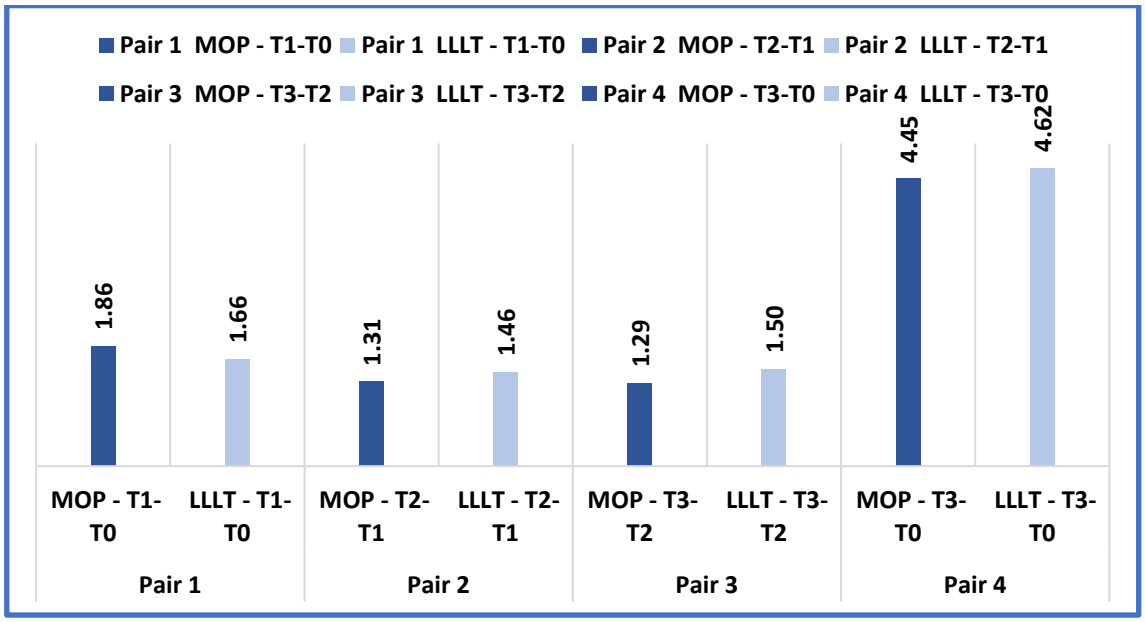
Table-12: Intergroup differences in Canine Rotation between MOP & LLLT

		Mean ± SD	Mean difference ± SD	t	p value
T0	MOP	37.19±4.25			
	LLLT	37.19±4.25			
T3	MOP	29.19±4.25	0.36±0.57	2.86	0.01
	LLLT	28.83±4.19			

Table-13: Intergroup comparison of Anchorage Loss at both T0 & T3

		Mean ± SD	Mean difference ± SD	t	p value
T0	MOP	7.19±2.06			
	LLLT	7.19±2.06			
T3	MOP	6.79±2.11	-0.05±0.52	-0.42	0.68
	LLLT	6.83±2.12			

Chart-7: Amount of Canine Retraction at all time frames in both (MOP & LLLT) groups



So, the Null Hypothesis is accepted in terms of Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage Control between MOP and LLLT Groups.

Discussion

With advancements in treatment modalities, new procedures are introduced that helps in reducing the treatment time and achieving faster treatment results, which nowadays becomes a major concern for orthodontic patients. Techniques to accelerate orthodontic tooth movement can either be categorized into Pharmacological, Physical and Surgical or into Invasive, Minimally Invasive and Non-Invasive. These procedures cause RAP and help in accelerating the OTM. The acceleration techniques are advantageous in terms of reduction in treatment duration, decline in risk of periodontal problems and dental caries and improvement in patient's motivation.

The present study was conducted to compare and evaluate the Rate of Canine Retraction, Root Parallelism, Canine Rotation and Anchorage Control when individual canine retraction is done with Micro-Osteoperforation and Low Level Laser Therapy.[19-33] In the present study, we found out that the OTM was accelerated for both MOP and LLLT side when compared at time T_0 and T_3. Further looking at individual time intervals, it was seen that the Rate of Canine Retraction was slightly higher in the MOP side compared to the LLLT side between T_0 and T_1. There is no significant difference found in the Anchorage Loss and Root Parallelism. However, the mean difference of Canine Rotation (0.36±0.57) between T_0 and T_3 seen in the MOP side is significantly higher than in LLLT side.

According to **Mani Alikhani et al,[21] Irfan Qamrruddin et al,[23] Allisa Maria Varella et al,[26] Ibadullah Kundi et al[28]** and **Sudhakar Venkatachalapathy et al**;[33] MOP[21,28,33] and LLLT[36,26] accelerate the OTM by two fold, which is similar in results with our study. In our study the rate of Canine retraction is almost similar in both MOP and LLLT side. According to study performed by **Laraway and Robert Dane[24]** and **Gauri Doshi-Mehta et al,[31]** OTM is increased by 40% and by 30% respectively with MOP compare to Conventional Control Group in split-mouth design.

According to **Tugba Haliloglu-Ozkan et al,[25]** there is no significant difference between canine rotation at T_0 & T_3, which is in the same equation as our study.

After evaluating the literature till date, there is no previous study that notify root parallelism after Canine Retraction.

According to **Tugba Haliloglu-Ozkan et al,[25]**there wasno significant difference in anchorage loss between Flapless Osteo-puncture experimental group and Conventional Control group. According to **Ibadullah Kundi et al,[28]** the molar mesialization on the experimental (MOP) side was observed to be 0.48 (0.11) mm while the control group was 0.66 (0.19) mm. In our study the Anchorage Loss when T_0 and T_3 were measured individually on the MOP side measured 0.4 (0.41) mm and the LLLT side measured 0.36 (0.39) mm. Amount of anchorage control in our study was synonymous with their conclusions.

Ahmed Nasef Abdelhameed[37], conducted study with split-mouth design, wherein the subjects were divided into 3 groups: Group 1 (MOP versus Control), Group 2 (LLLT versus Control) and Group 3 (MOP-LLLT versus Control). They concluded that LLLT in conjunction with MOP delivered optimum acceleration when

compared with each technique separately. The retraction of 3.86 ± 0.27 mm was attained after 8 weeks. While in our study a retraction of 3.17±0.37 on the MOP and 3.11±0.52 on the LLLT side was attained after 8 weeks. According to **I. Bajaj et al**[38], the MOP Group had 1.1 times more retraction than the Photobiomodulation (PBM) Group. They aimed at assessing the outcome of PBM & MOP on the rate of orthodontic tooth movement. Their sample consisted to thirty selected samples which were studied in a split mouth design for the rate of canine retraction over a 4 month time period. The frequency of PBM was 1st, 3rd, 7th, 15th, 30th, 60th and 90th day. Irradiation on 10 sites for 10 secs each was fixated at 970nm. And three MOPs were performed distal to the side of canine root by Propel-TM. They measured 1.28 mm/month OTM on the MOP & 1.16 mm/month on the PBM side.

There were no studies that compared all the four parameters (Rate of Canine Retraction, Canine Rotation, Root Parallelism and Anchorage control). Thus, present study was conducted as a split mouth design comparing both MOP & LLLT techniques that are well-known in current clinical orthodontic scenario.

Further research can be carried out to explore newer and advanced techniques which accelerate orthodontic tooth movement with minimal damage to periodontium and negligible patient discomfort to accomplish best possible treatment outcomes.

Conclusion

- ✓ There was no statistically significant difference found in Rate of Canine Retraction, Root Parallelism and Anchorage Control between MOP and LLLT Group.
- ✓ Incidence of higher disto-palatal rotation of canine was seen in MOP Group compared to LLLT Group, but was not statistically significant.

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