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'Comparative Evaluation of the Effect of Modified Mop on Orthodontic Tooth Movement– A Prospective Clinical Study.'

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ABSTRACT-
Objective: The present study aimed to evaluate the effect of MOP over a 3-month period and to determine theinfluence of the number of perforations on the rate of canine retraction. In addition, the amount of pain anddiscomfort caused by the MOP method was evaluated.
Methods-The current study is a split-mouth randomized controlled trial with 1:1 allocation ratio.The clinical trial was in the orthodontics department oftriveni institute of dental sciences,hospital and research centre. Twentypatients who need fixed orthodontic treatment were selected. In each patient one side of the mouth worked as acontrol side which received no MOPs. Four months after first premolars extraction, patients received3 MOPs on the buccal surface of alveolar bone in the experimental side to accelerate canine retraction. The amount ofcanine retraction was measured every 28 days at three intervals on both sides of the mouth. Pain perception wasalso measured on the day of MOP procedure and subsequently at 24 h.
Results:The mean distance moved by the canines in the control and MOP sides were 0.98 ±0.05mm, 1.06 ±0.06mm, 0.71 ± 0.05mm, 0.89 ±0.05 mm; and 1.12 ±0.05mm, 1.40 ±0.13mm,0.91 ±0.05mm, and 1.01 ±0.05 mm in the first, second, third, and fourth months respectively, with significant statistical difference (P > 0.05) at any observation time. The mean rate of canine retraction was 0.91 ± 0.3 mm/month in non-MOP side and 1.1mm in MOP side.
Conclusion:The MOP interventions were effective in accelerating the magnitude as well as overall rate of canine retraction on MOP side at all the time points, which was statistically significant.Majority of patients in our study did experience mild to moderate level of pain on the MOP site during the first two days, which gradually diminished and disappeared within a week with no other complications.

I. INTRODUCTION

In children and teenager patients, human growth can be utilized to aid inorthodontic and orthopaedic treatment of the dental and skeletal malocclusions. However,adult patients have little to no growth remaining. Therefore, orthopaedic approachescannot be utilized, often prolonging treatment and increasing the risk of potential side-effects such as gingivitis and periodontitis[1], decalcification, caries[2], and root resorption[3].In addition to potential side effects,"Oral health related quality of life" (OHRQOL) of adultsis altered during fixed treatment. There is a decrease in one's personal self-esteem duringtreatment. Therefore, it is critical to explore safe modalities to accelerate orthodontic tooth movement, which in turn reducestreatment time for adults[4].

The number of adult patients seeking orthodontic therapyhas increased considerably over the last few years. The demandfor shorter treatment duration has set precedent for researchersto look at newer paths to shorten treatment duration withoutcompromising on the efficiency of the treatment[5].Micro-osteoperforation (MOP) is an acceleratory methodwhich has been lately proposed[6]. Unlike corticotomy, thisprocedure comprisesof flapless bone puncturing. This minorsurgical procedure was first introduced by Teixeira et al[6], who hypothesized that limited cortical bone perforationswere sufficient to elicit Regional Acceleratory Phenomenon (RAP), hence acceleratingorthodontic tooth movement (OTM).

Nevertheless, later experimental studies[7-10]haveshown conflicting evidence regarding its acceleratory effect.The first human trial conducted by Alikhani et al[11]reported that MOPs were able to increase the rate ofOTM by 2-3fold.Alkebsi et al[12]demonstrated that MOPs were not effective for accelerating OTM; hence, the effect of MOP on OTM still remains indistinct.

Therefore, the concentration for this study was to provide evidence-based research for osteoperforations of cortical bone in relation to accelerating OTM in adult patients.

AIM:

- To determine the effect of modified MOP procedure on orthodontic tooth movement and compare it with the other side.

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OBJECTIVES:

- To measure the rate and total amount of tooth movement when followed by MOP procedure (during canine retraction in order to close 1st bicuspid extraction space)
- To evaluate pain associated with the procedure on a numerical pain scale with rating of 1 to 10.
- To compare these effects with the opposite side of the same arch. (without MOP)

HYPOTHESIS:

- **Alternative Hypothesis (H_1):** Rate of tooth movement is greater on the experimental side treated with micro-osteoperforations of cortical bone than the control side in adult patients.

- **Null Hypothesis (H_0):** There is no significant difference in the rate of tooth movement between the experimental side treated with micro-osteoperforations of cortical bone and the control side in adult patients.

II. MATERIALS AND METHOD:

The current study was a split-mouth randomized controlled trial with 1:1 allocation ratio. The study procedures were approved by the Institutional Ethical Committee of Triveni Institute of Dental Sciences, Hospital and Research Centre. Twenty subjects were selected from the outpatient clinic of the Department of Orthodontics and Dentofacial Orthopedics, Triveni Institute of Dental Sciences, Hospital and Research Centre, who were acquainted with the study procedures and radiation exposures. Written consents were then signed by the subjects.

INCLUSION CRITERIA

- Adult males and females ranging between 18 and 30 years,
- Subjects requiring bilateral extraction of the maxillary first premolars and canine retraction with maximum anchorage,
- Subjects with full permanent dentition with exception of the third molars,
- Subjects with good oral hygiene and sound periodontal condition.

EXCLUSION CRITERIA

- Medically compromised patients,
- Subjects with chronic use of medications affecting OTM, and habits like smoking,
- Any radiographic evidence of bone loss.

Sample size calculation

Based on a previous study[79], the mean change in the active and control groups was 1.53 ± 0.67mm and 0.78± 0.24mm respectively. The sample size was calculated based on Type I error probability (0.01), in which the response within each subject group was normally distributed with standard deviation of 0.503. The power analysis showed that 15 subjects were needed to be able to reject the null hypothesis and that the population means of the active and control sides were equal with probability(power) 0.9. Considering dropouts, a sample size of 20 patients was considered appropriate.

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FIG. 1 ARMAMENTARIUM, 2 MOP PROCEDURE, 3. RETRACTION ON MOP AND CONTROL SIDE, 4. DONTRIX GAUGE WAS USED TO MEASURE THE CONSTANT FORCE, 5. MEASUREMENTS WERE DONE USING DIGITAL CALLIPER

III. RESULTS-

Statistical analysis

The data was tabulated in Microsoft Excel software and analyzed with SPSS V.24 software.

Independent t test and Paired t test were used for the comparisons between the groups. The p value≤0.05 was considered as statistically significant.

Result

Twenty patients were recruited and completed the study with no loss to follow-up. The subjects were selected from patients that came to the Department of Orthodontics at Triveni institute of Dental sciences for comprehensive orthodontic treatment between September 2020 and March 2021. The age range of the patients was 18–30 years (mean 20.5 ± 3.85 years).amount of canine retraction was measured in cast every month and the time intervals are T0(before initiation of canine retraction),T1(end of first month),T2(end of second month) ,T3(end of third month),T4(end of fourth month).By the end of the fourth month of canine retraction, complete space closure was achieved in 15 patients, 3 patients needed further 1 month of canine retraction, and complete space closure was achieved after 3 months in 2 patient.

The mean distance moved by the canines in the control and MOP sides were 0.98 ±0.05mm, 1.06 ±0.06mm, 0.71 ± 0.05mm, 0.89 ±0.05 mm; and 1.12 ±0.05mm, 1.40 ±0.13mm,0.91 ±0.05mm, and 1.01 ±0.05 mm in the first, second, third, and fourth months respectively, with significant statistical difference (P > 0.05) at any observation time. (Table1 & Fig 1) The mean rate of canine retraction was 0.91 ± 0.3 mm/month in non-MOP side and 1.1mm in MOP side.

Comparison of tooth movement in different time between the groups

The mean rate at all the time intervals as well as the mean rate of canine movement was found to be higher in the side where microosteoperforation was performed when compared to opposite (control) side.

Table 1. Comparison of tooth movement in different time between the groups

Time	Group	Mean	SD	Mean difference	95% confidence interval of the difference		P value
					Lower	Upper	
T1	With MOP	1.12	0.05	0.14	0.10	0.17	0.000*
	Without MOP	0.98	0.05				

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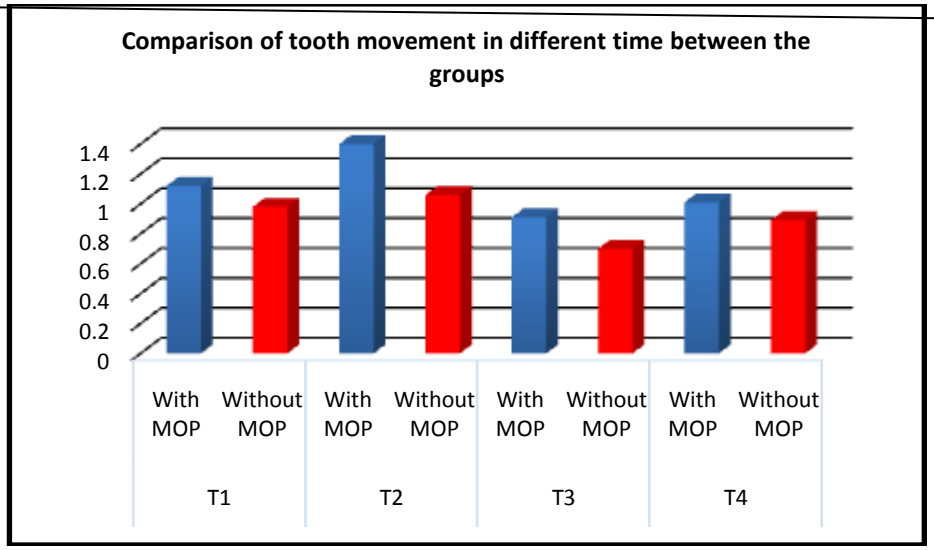
T2	With MOP	1.40	0.13	0.34	0.27	0.40	0.000*
	Without MOP	1.06	0.06				
T3	With MOP	0.91	0.05	0.21	0.16	0.23	0.000*
	Without MOP	0.70	0.05				
T4	With MOP	1.01	0.05	0.12	0.09	0.16	0.000*
	Without MOP	0.89	0.05				

*Statistically significant differences exist between the groups



Comparison of tooth movement between different times in Group with MOP

The mean tooth movement on MOP side was found to be highest in the second month (T2-1.40 ±0.13mm) when compared with mean movements among different time intervals.

Table 2. Comparison of tooth movement between different times in Group with MOP

Time		Mean	SD	Mean difference	95% confidence interval of the difference		P value
					Lower	Upper	
T1 vs. T2	T1	1.12	0.05	0.28	0.23	0.33	0.000*
	T2	1.40	0.13				
T2 vs. T3	T2	1.40	0.13	0.49	0.44	0.54	0.000*
	T3	0.91	0.05				
T3 vs. T4	T3	0.91	0.05	0.10	0.08	0.13	0.000*
	T4	1.01	0.05				

*Statistically significant differences exist between the times

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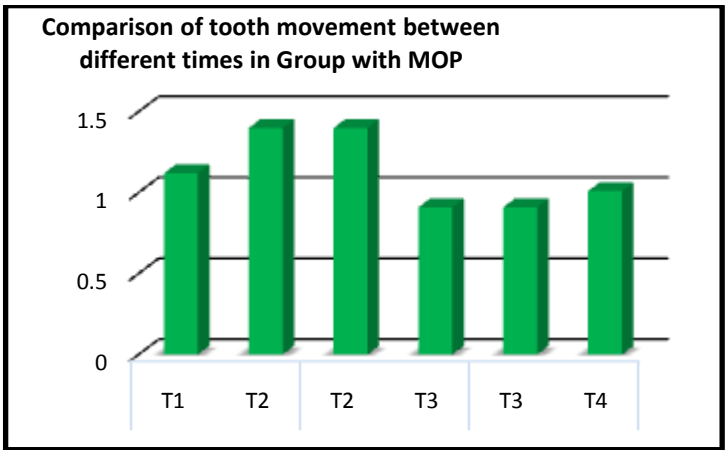


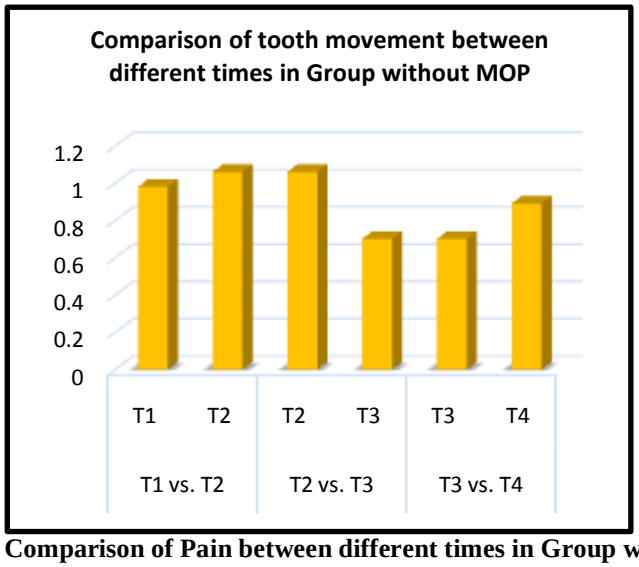
Comparison of tooth movement between different times in Group without MOP

The mean tooth movement was found to be highest in the second month (T2-1.06 ±0.06mm) in non-MOP group when compared among different time intervals.

Table 3. Comparison of tooth movement between different times in Group without MOP

Time		Mean	SD	Mean difference	95% confidence interval of the difference		P value
					Lower	Upper	
T1 vs. T2	T1	0.98	0.05	0.08	0.07	0.09	0.000*
	T2	1.06	0.06				
T2 vs. T3	T2	1.06	0.06	0.36	0.33	0.38	0.000*
	T3	0.70	0.05				
T3 vs. T4	T3	0.70	0.05	0.19	0.15	0.20	0.000*
	T4	0.89	0.05				

*Statistically significant differences exist between the times



Comparison of Pain between different times in Group with MOP

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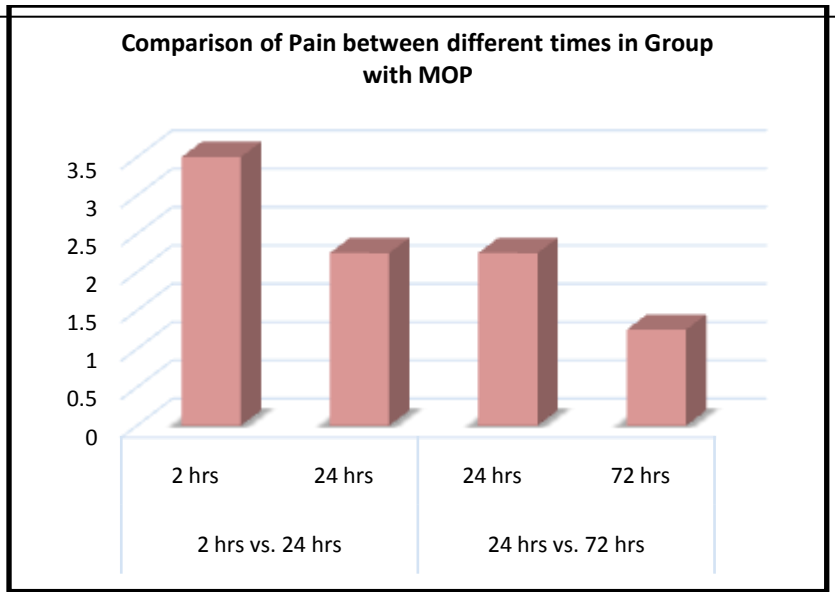
The mean pain scores of the patients on the day of MOP procedure, after 2 hrs,24 h, and 72 hrs were 3.50± 0.82, 2.25 ± 0.71, 1.25 ± 0.63, respectively.(Table.4 & Fig 4).

Majority of patients experienced maximum pain following the procedure once the effect of anaesthesia weared off(2 hrs), when enquired after 24hrs the pain was mild and in 72 hrs pain and discomfort subsided for most of the patients.

Table 4. Comparison of Pain between different times in Group with MOP

Time		Mean	SD	Mean difference	95% confidence interval of the difference		P value
					Lower	Upper	
2 hrs vs. 24 hrs	2 hrs	3.50	0.82	1.25	0.82	1.67	0.000*
	24 hrs	2.25	0.71				
24 hrs vs. 72 hrs	24 hrs	2.25	0.71	1.00	0.51	1.48	0.000*
	72 hrs	1.25	0.63				

*Statistically significant differences exist between the times



Responses to Question 1 (Which side is more painful)
majority (85%) of the patients answered that the MOP side was more painful than the control side (Table.5 & Fig.5)

Table 5. Responses to Question 1 (Which side is more painful)

Responses	N	%
MOP side	17	85
Control side	2	10
Same	1	5

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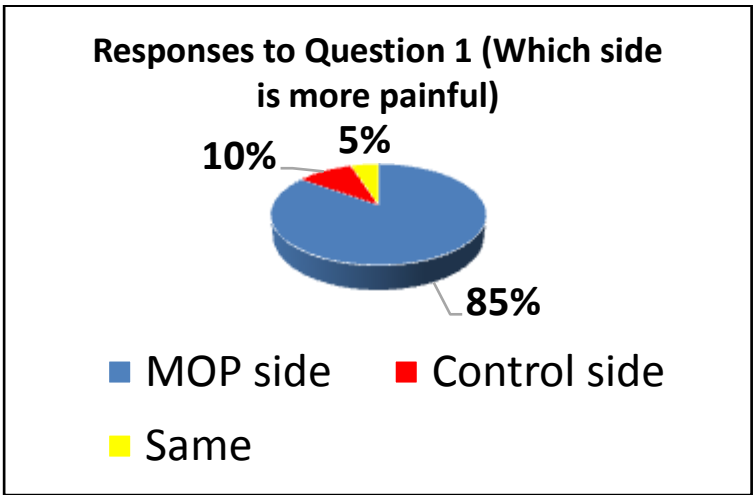
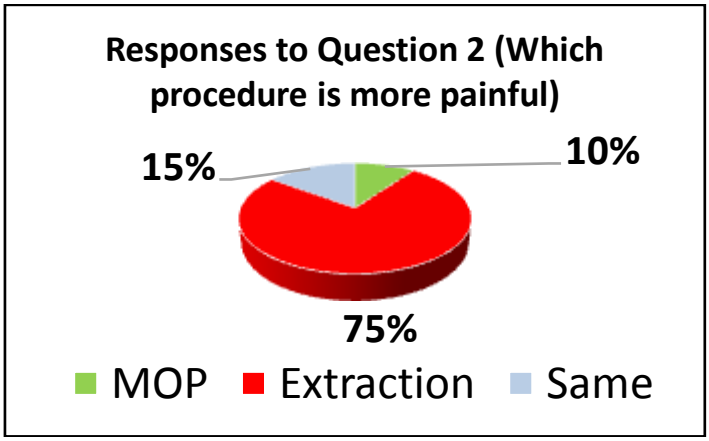


Responses to Question 2 (Which procedure is more painful)

Results of **Question 2** were as follows: 10% of the patients answered that MOP was more painful, 75% of the patients answered that extraction was more painful, 6% of the patients answered that they were equally painful, and 15% of the patients did not know which procedure was more painful. (Table.6 & Fig.6) **Majority of patient stated that they found extraction of bicuspid more painful than the microosteoperforation procedure**.

Table 6. Responses to Question 2 (Which procedure is more painful)

Responses	N	%
MOP	2	10
Extraction	15	75
Same	3	15



IV. DISCUSSION-

It is generally accepted that the rate of tooth movement is controlled by the rate of bone resorption, which in turn is controlled by osteoclastic activity. Therefore, one can assume that the factors recruiting osteoclast precursors from the circulation and stimulating the differentiation of these cells into osteoclasts, should play significant roles in tooth movement. Many studies have reported an increase in the activity of inflammatory markers such as chemokines and cytokines in response to orthodontic forces.many

studies were conducted to evaluate the effectiveness of surgical and non-surgical adjunctive procedures aiming to accelerate orthodontic tooth movement (OTM) such as adequate use of brackets, controlling force levels and relying on less friction bracket systems, photo-biomodulation, pharmacological approachesand low-intensity laser irradiation.

Among all modalities introduced,corticotomy has the largest number of research evidence regarding its efficacy in reducing orthodontic treatment time due to the regional acceleratory phenomenon (RAP). However, it is a relatively invasive procedure with low patient acceptance. As a direct result, minimally invasive flapless methods such as corticision, piezocision, and micro-osteoperforation (MOP) have been proposed.

Among the surgery-assisted techniques, MOP is a new method to accelerate orthodontic tooth movement through small perforations in the alveolar bone without requiring raising flaps, bone graft, or suture in our current study. However, there is limited and contradictory evidence on the efficacy of this procedure.

TO EVALUATE EFFECT ON CANINE RETRACTION -

Our results showed that, there was a significant increase in the rate of canine retraction compared to the contralateral control side at all time intervals. The mean rate of canine retraction was 0.91 ± 0.11 mm/month in non-MOP (control) side and 1.11± 0.15mm/month in MOP side. Also, the maximum amount of tooth movement on MOP side was found to be in the second month (T2- 1.40 ±0.13mm) with highest difference in tooth movement when compared to the control side (0.34 mm) was seen during same time interval. Which infers to the fact that the effect of MOP is seen to be in peak during second month and then decreases gradually and matches to the rate of control side later because osteoclast recruitment has been found to peak at 4weeks and gradually reduced by 12 weeks. This was similar to the result of study conducted by **Aishwarya et al[5](2020)**

- **Alikhani et al[11] (2013)** 11 conducted a study and concluded a higher mean difference of 0.63 mm retraction per month in the presence of MOP. Our study result showed similar result as there was increased rate of tooth movement at all the time intervals (0.19 mm). This difference in amount of movement could be due to tendency of overestimation in amount of tooth movement when measured intraorally by direct method.
- **Feizbakhsh et al[13] (2018)** 74 conducted a clinical trial to evaluate the effect of MOP in rate and amount of tooth movement during canine retraction and came to the conclusion that MOPs significantly increased the rate of tooth movement by more than twofold in comparison to control group. The average rate of tooth movement in the interventional side was 1.3 mm/month. Our present study also showed similar result of increased rate of canine retraction on MOP side (1.11± 0.15mm/month) when compared with control side.
- **Abdelhameed et al[14](2018)** 113 performed a study to evaluate the effect of combined low-energy laser application and MOPs vs the effect of application of each technique separately on the rate of orthodontic tooth movement. They found the rate of tooth movement on the MOP side was 1.8 mm/month and that MOP increased the rate of tooth movement by 1.6 times in comparison to the control group. In our current study the rate of canine retraction on the MOP side inferred to similar increase (1.11 ± 0.15 mm/month) and amount of tooth movement was found to be higher than control side at any time interval, which are in agreement with the above study.

TO EVALUATE PAIN PERCEPTION ASSOCIATED WITH MICRO-OSTEOPERFORATION-

- The primary objective of all minimally invasive surgical procedures was to achieve accelerated OTM utilizing patient-friendly approaches; consequently, patients' feedback regarding pain and discomfort associated with the MOP procedure was of utmost importance. However, in our current study, majority of patients had mild to moderate pain, specially related to function, following the effect of anaesthetic wear off; which disappeared gradually from third day onwards which is in line with previous study results

Abolanga et al[15] (2019) in their trial used the Numeric Pain Rating Scale, which allows calibrating pain intensity from 1–10. They found that the pain severity experienced by the patients ranged from mild to moderate pain that rapidly faded away after 1 week. Also, while answering the questions asked regarding the experience during MOP, majority of patients found MOP side more painful than the control side and extraction was associated with more pain. Our study results are similar regarding pain experienced.

V. CONCLUSION-

Longer treatment time with fixed orthodontic treatment is associated with an increased amount of side effects such as demineralization of the enamel and root resorption. In addition, the costs of an orthodontic treatment often increase proportionally to its duration, while the motivation of the patient is inversely related to treatment duration. The increased demand for rapid orthodontic treatment has led to the introduction of several methods. The introduction of accelerated orthodontic tooth movement (AOTM) with minimally invasive techniques has decreased treatment duration and increased patient acceptance toward treatment over the past decade such as corticotomies, periodontal distraction, use of low-level lasers, mucoperiosteal flap surgery, piezocision (PZ), and micro-osteoperforation (MOP).

In our present split-mouth randomized study we examined the influence of micro-osteoperforation on maxillary canine retraction and compared it to the rate of canine retraction on opposite (control) side of the arch to establish the place of MOP as a routine chairside procedure to accelerate tooth movement in daily orthodontics. The difference in rate of tooth movement were measured and compared with control side as well as pain perception associated with MOP were evaluated to check patients' acceptance for the procedure.

The findings of the present study infer toward following conclusions:

- The MOP interventions were effective in accelerating the magnitude as well as overall rate of canine retraction on MOP side at all the time points, which was statistically significant.
- The increase in rate of canine retraction was maximum during the second month of study and reduced in following months, which infers to the need for repeated MOP to achieve optimum result of MOP and a constant spurt in rate of tooth movement.
- Majority of patients in our study did experience mild to moderate level of pain on the MOP site during the first two days, which gradually diminished and disappeared within a week. No other complications were reported indicating the technique can be used as a safe adjunct during routine orthodontic therapy to accelerate tooth movement.

However further studies will be required to check the clinical significance of the MOP in reduction of overall treatment time and whether the results worth the cost and invasiveness of this procedure. Also, the ideal interval for repeating the perforations to gain optimum and constant result from MOP has to be investigated in detail.

VI. LIMITATIONS-

The limitations of this study are the following:

- The sample size in the present study was 20 sites; the sample size was probably too small for the pain assessment. Further studies with larger sample size are required to validate the results of this study.
- Alginate impressions were used to fabricate dental casts which in turn were used to measure the tooth movement; it surely would provide much accurate measurements if advanced method such as 3D –CBCT was employed instead.
- The current study did not evaluate the effect of different numbers, sites, and repetition of MOP on the rate and type of tooth movement.
- It was a short-term clinical study with only a 4-month follow-up period, which did not evaluate the effect of MOP on the overall treatment duration.
- The effect of the intervention on inflammatory markers was not evaluated.
- Potential side effects of orthodontic tooth movement and MOPs such as root resorption and crestal bone resorption were not evaluated.

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