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Micro Osteoperforations – A Comprehensive Review

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Abstract:
The current trend in orthodontics is incorporation of methods to expedite the treatment while achieving a satisfactory outcome by increasing the rate of orthodontic tooth movement as well as increasing treatment efficiency. Inspired by the regional acceleratory phenomenon, researchers have made numerous efforts to utilize this phenomenon to deliberately increase the rate of orthodontic tooth movement and shorten the treatment duration. Studies have evaluated various surgical and non-surgical interventions to induce inflammation to increase the rate of orthodontic tooth movement. Micro-osteoperforation (MOP) is a newly introduced technique that can easily be performed in an office setting with minimal patient discomfort to increase the rate of orthodontic tooth movement. [10] *The primary objective of this article is to elucidate the mechanism, advantages of MOP, application techniques of MOP, Areas of MOP in detail to achieve desired outcome*
Keywords: *Micro-Osteoperforation [MOP], Orthodontic Tooth Movement[OTM]*

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I. Introduction

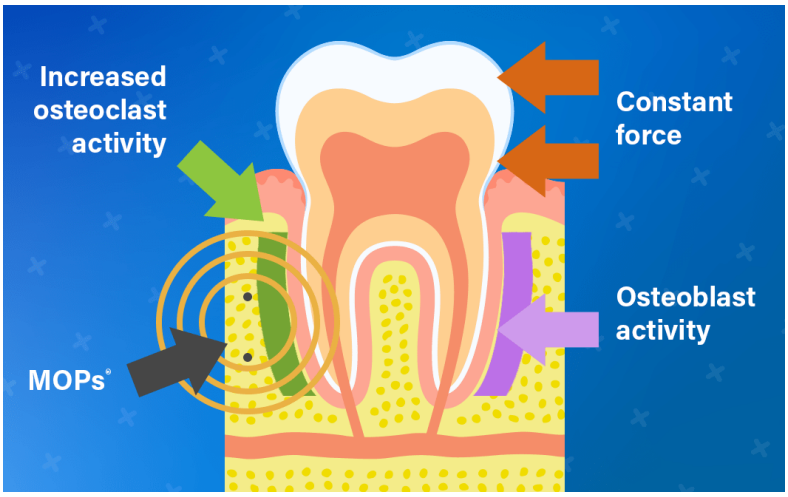
One of the main challenges in orthodontics today is the desire to decrease treatment time without compromising treatment outcome. To achieve this, we need to understand the three variables that can control the duration of treatment. First, there are practitioner-dependent factors, such as proper diagnosis and treatment planning, mechanotherapy, selection of appliances, and delivery of treatment in a timely fashion. Second, we have patient-dependent factors, such as maintaining appointments, good oral hygiene, integrity of the appliances, and following the practitioner's instructions. The third factor is regulated by the individual's biology and to a certain degree under the control of the practitioner.[1]

Hence, the current trend in orthodontics is incorporation of methods to expedite the treatment while achieving a satisfactory outcome by increasing the rate of orthodontic tooth movement as well as increasing treatment efficiency. In an attempt to accelerate the rate of orthodontic tooth movement, many studies have investigated the biological mechanism of orthodontic tooth movement and how to manipulate the physiology.

Micro osteoperforations in orthodontics is a procedure in which small pinhole perforations are created in the bone around the teeth to accelerate the rate of tooth movement during orthodontic treatment. This novel method of accelerate tooth movement is based on the natural inflammatory response of the body to physical trauma.[13]

This technique was first perfomed by teixeria in his animal model by creating shallow perforations, the term Micro osteoperforations was first proposed by Mani Alikhani[9,10]

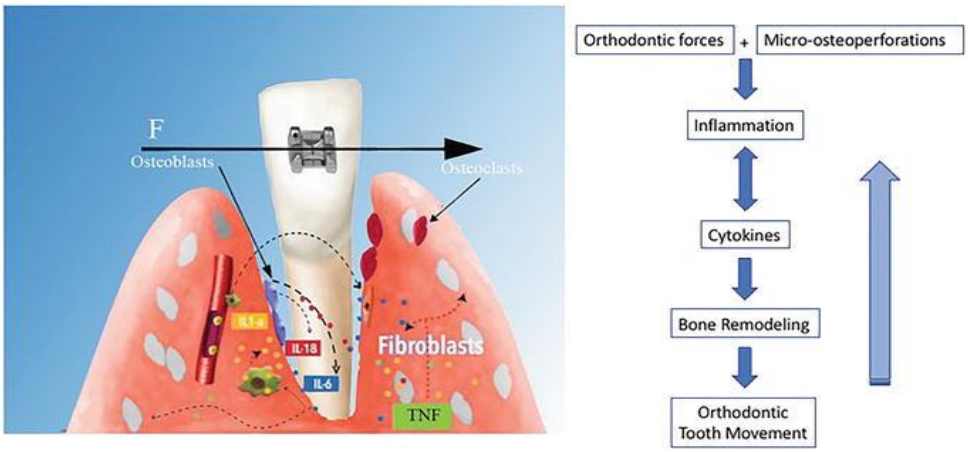
That controlled micro-trauma in the form of micro-osteoperforations (MOPs; which maintain the integrity and architecture of hard and soft tissue) will amplify the expression of inflammatory markers that are normally expressed during orthodontic treatment and that this amplified response will accelerate both bone resorption and tooth movement.[13]



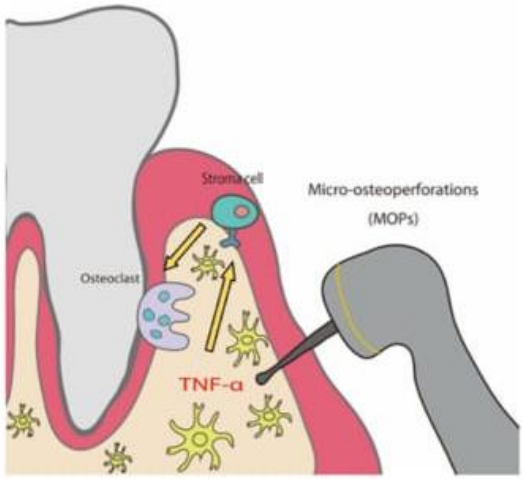
Micro-osteoperforation is an up-to-date procedure which is promoted as an auxiliary dentoalveolar procedure which can accelerate tooth movement via minimum surgical interventions.

Mechanism Of Mop

MOP significantly stimulated the expression of inflammatory markers [cytokines and chemokines] and significantly increased the number of osteoclast and cause bone resorption and with the increase in bone remodelling was not limited to that area of the moving tooth, but extended to the tissues surrounding the adjacent teeth.



Ria Kinjo et al in 2022 suggests that MOPs increases orthodontic tooth movement distance and TNF – alpha expression. The responsiveness of stromal cells to TNF – alpha is a crucial factor for osteoclast formation, and MOPs amplify this response, leading to increased movement distance during orthodontic tooth movement.[53]



Advantages Of Mop

Advantages of Micro-osteoperforations

When compared to other surgical approaches to accelerate tooth movement, it is obvious that MOPs offer a number of advantages. This procedure is minimally invasive and flapless and can safely be performed by the orthodontist.

Corticotomy or piezoincision procedures, on the other hand, require either the reflection of a fullthickness flap to expose the buccal and lingual alveolar bone or soft tissue incisions, followed by interdental cuts through the cortical bone. Recently, a modification of this technique has been introduced where, after selective decortication in the form of lines and points, a resorbable bone graft is placed over the surgical site. The effect of this technique has been incorrectly attributed to the shape of the cuts made into the bone (block concept) and to the bone grafts. The rate of tooth movement is controlled by osteoclast recruitment and activation. Therefore, regardless of the shape or the extent of the cut, bone resorption will not occur unless osteoclasts are activated. This means that, similar to micro-osteoperforations, the effectiveness of corticotomy or piezoincision can be related to the activation of cytokines that are released in response to the trauma induced during the cuts. The release of cytokines is expected to be significantly higher in corticotomy and piezoincision in comparison with micro-osteoperforations due to the more invasive nature of these procedures and the extensive trauma to the bone. Unfortunately, similar to micro-osteoperforations, the increased level of cytokines will not be sustained for a long period of time with these procedures and will eventually return to normal levels. Therefore, repeating these procedures to maintain the desired level of cytokine activity requires significant cost and time commitment for the patient due to the need for the services of another specialist, periodontist, or oral surgeon.[10]

Mop Application Techniques

Mop Armamentarium And Setup

All tools should be available and accessible before the procedure is initiated. To perform MOPs, the following instruments and materials are recommended:

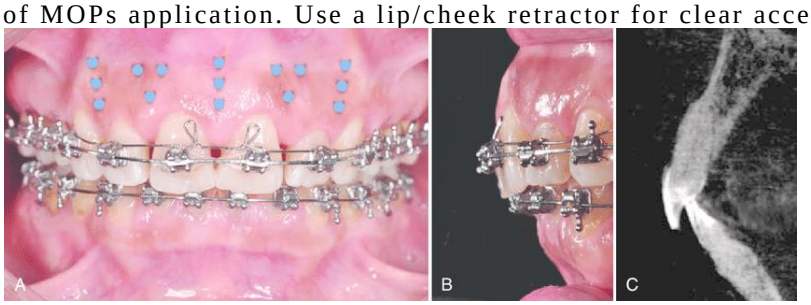
- MOPs tool,
- Chlorhexidine oral rinse solution,
- Gauze/cotton rolls,
- Cheek retractor,
- Topical and local anesthesia,
- Carpule syringe and needle gauge,
- College plier and mouth mirror,
- Periodontal probe,
- Suction and water syringe.[13]

Mop Procedure

The following protocol is used to perform the MOPs procedure:

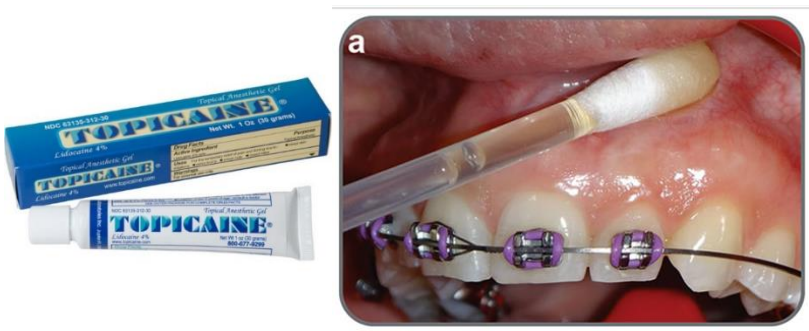
Ask the patient to rinse his/her mouth with 15 ml of chlorhexidine oral solution for 30 s.

Select the area of MOPs application. Use a lip/cheek retractor for clear access.



To eliminate excess saliva and dry the location, wipe the area with a wet gauze or cotton roll.

Apply topical anesthesia on the area planned for anesthetic injection and leave for 1–2 min.



Start local infiltration with fine needle tip. The amount of anesthesia for one location is about one fourth carpule or less. Wait a few minutes after the injection and use a probe or explorer to check if the area is sufficiently anesthetized.

Set up sterile MOPs tool with a disposable tip set to the appropriate length, and gently perforate the cortical plate in the area of interest with a light stable rotation movement. Remove the tool gently by rotating in the opposite direction after perforation reaches the set depth.

Slight bleeding is normal and can be stopped using wet gauze/cotton pressed on the MOPs site.
Evaluate the area.[13]

Mops POST OPERATIVE CARE

In case of discomfort patient is advised to take pain medication, such as acetaminophen. Anti-inflammatory medication (such as non-steroid anti-inflammatory drugs) should not be prescribed as such drugs inhibit the inflammatory effect of MOPs,

thereby rendering the procedure ineffective. In case of poor oral hygiene or in patients with compromised health, chlorhexidine rinses are recommended. Advise the patient not to change their brushing and flossing habits in the area where MOPs have been applied.[13]

Mop Application Tools

Various tools have been used for employing minimally invasive micro-osteoperforation, based on different types obtained from the literature they are grouped as

- Burs
- Commercially available devices
- Mini-implants or Mini-screws

Burs

In animal studies burs are commonly used to create shallow perforations, the commonly used burs are

- Round bur with slow speed handpiece – diameter 0.25mm and depth 0.25mm
- Straight fissure bur with slow speed handpiece – diameter 1.0mm

Initially Teixeria uses burs to create shallow perforations on experimental animal models, further animal studies also used the burs to create shallow perforations on the animal models that mimics the MOPs on the human model [12,42]

Teixeria used round bur and handpiece with diameter of 0.25mm and depth of 0.25mm, the other animal study uses ¼ round bur with low speed handpiece with diameter of 0.25mm and depth of 0.25mm and straight fissure bur with the diameter of 1.0mm at 600rpm to create multiple horizontal micro-osteoperforations and uses straight fissure bur with the diameter of 1.4mm at 600 rpm to create single vertical micro-osteoperforations using ¼ round bur with a low-speed handpiece for creating shallow osteoperforations.[12,42]

Commercially Available Devices

Propel Device

Propel was introduced by Propel Orthodontics, Ossining, New York. This device is a single use, sterile, disposable manual perforator similar in size to a small handheld screw driver. The device has a pointed surgical stainless steel tip of 1.6 mm in diameter at its widest aspect and with a usable length upto 7.0 mm. The device has protective sleeve that allows pre-setting depths at 1.0, 3.0, 5.0 and 7.0mm respectively, the single use perforation screws are individually packed and sterilized with gamma radiation. It has a light signal, that turns on when the desired perforation depth is reached.[10]

Mani Alikhani was the first to use the propel device for micro-osteoperforation, followed by him other authors used propel device for Micro-osteoperforation and proves MOP as an effective procedure in accelerating tooth movement. [16-18,26,28,33,37,38,44]

Alikhani and a group of researchers had patented the propel device for MOP procedure and licenced the same for commercial production

Mini-Implants Or Mini-Screws

Thus Mini-implants are a convenient tool that is already commonly used by orthodontist,

The mini-implant was marked to ensure a consistent MOP depth of 1mm after reaching the depth, the mini-implant was removed using reverse function of the slow speed driver engine, thus successfully creating a shallow, consistent perforation in the alveolar bone

This mini-implants can be automated machine driven or hand driven MOPs using handpiece and commercially available device specifically designed for MOP creation have been developed for minimally invasive accelerated tooth movement treatment options, eliminating the need for concomitant periodontal surgery. By this mini-implant the alveolar perforations are created by inserting and removing. This utlilization of conventional orthodontic mini-implants for MOP creation offers great potential because they are readily available in orthotic offices and most orthodontist are already trained in the use of mini-implants. The universal acceptance and wide usage of orthodontic mini-implants should also help patient acceptance because many orthodontic patients are already familiar and comfortable with mini-implants. Furthermore, this method potentially allows for more consistent and uniform defects to be created compared with previously used MOP methods such as round burs.

Tracy Cheung was the first to use of mini-implant as a tool for micro-osteoperforation in his animal study with 1.2 mm in diameter, 1.0 mm depth using an automated pre-programmed slow-speed implant driver at a constant torque of 30 rpm.

Commonly used commercially available mini-implants or mini screws for creating micro-osteoperforations are

- Piolet drill [Bio Materials Korea] with the diameter of 1.2mm,
- Aarhus mini-implant system [American Orthodontics] of 1.5mm diameter and 6mm length, Dual top mini-implant [Jeil Medical Corp, Seoul, Korea] with 1.2mm diameter and 6mm length,
- Screw driver device with 1.6mm diameter and 3.0mm length,
- A mini-screw [MTN-2, Design Med, Istanbul, Turkey] with a diameter of 1.6mm and a length of 8mm,
- Orlus extra thread mini-implant [Ortholution.com] with the width of 1.6mm and length of 6mm,
- Dentarum mini-implant 1.6mm width and 8mm length,
- TAD [Unitek] 1.8mm in diameter and 8 mm in length,
- Favanchor mini-implant with diameter of 1.6mm and length of 8mm to perform MOP.

Based on the results of the studies, which demonstrate that mini-implant– facilitated MOPs successfully accelerate tooth movement, mini-implants are an attractive method for

MOP placement with promising clinical acceptance from both orthodontic patients and orthodontists.[14,15,20,21,22,23,25,29,36,45]

Areas Of Mop Application

Area of application

The maximum effect can be obtained when MOPs are applied close to the target teeth and far from the anchor teeth. MOPs are done usually in the buccal surface between the roots, on the alveolar ridge (in case of extraction) or, if needed, in the lingual surface between the roots. If the mechanical design provides precise force application in a certain direction, MOPs should be applied around the target tooth to encourage more bone remodelling. It is possible to encourage movement in the desired direction by focusing the MOPs application in one direction, compensating for mechanical shortcomings in guiding precise movement.

Height

The superior and inferior limits of MOPs can be determined in relation to the mucogingival junction (MGJ). MOPs should be placed within the attached gingiva to 1 mm apical to the MGJ. When a resistance toward root movement is observed, MOPs are placed more apically.[13]

Mesiodistal position

Root location and angulation should be considered while performing MOPs. MOPs should be applied mesial and distal to the root of the tooth to be moved.[13]

Buccal/lingual placement

Micro-osteoperforations can be applied in both buccal and lingual cortical plates. The buccal cortical plate is the most favourable place for placement of MOPs. However, when the lingual cortical plate affects the movement of the tooth, MOPs can be applied in the lingual plate. In this regard, contra-angle appliances are used to facilitate MOPs application in the lingual plate. In cases where bone resorption significantly decreased the width and height of alveolar bone, thereby decreasing buccal and lingual cortical bone, MOPs can be applied on top of the ridge.[13]

Mani Alikhani was the first to performed MOP distal to the canines in the extracted 1st premolar region and it should be at an equidistance from the canine and second premolar, other authors also suggested the same area of application. [18,25,26,29,33,34]

In another study they performed MOP on both mesial and distal aspects of the selected first premolar in the buccal alveolar region before extraction, these perforations are place in the mid-root region approximately at 5 to 8mm below the gingival crest.[17]and other study Performed MOP with the distance of 3 mm distal to the canine and 6mm from the free gingival margin[14,32]

MOP placement distally to canines as close to the apical as possible and equidistant between the anterior teeth region is to achieve more bodily movement. [24,21,37,35]

In another study they performed MOP directly through the alveolar mucosa in the middle of the distance between the distal surface of canine and the mesial surface of 2nd premolar at the extraction site in the buccal area for group 1 and in both buccal and palatal area for group 2. [36]

The other author placed MOP buccally and palatally in between the canine and lateral incisor root and in between the canine and the socket of extracted 1st premolar. [39]

Based on the overall review of literature the maximum effect can be obtained when MOPs are placed at an equidistance in the extraction space or in between the target area either on buccal or palatal/lingual cortex approximately 5 to 8 mm below the gingival crest by placing the MOP in the extraction space at an equidistance the accidental injury to the root can be avoided and can be easily performed in the wide extraction space without any interferences and The maximum effect can be obtained when MOPs are applied close to the target teeth and far from the anchor teeth. MOPs should be applied around the target tooth to encourage more bone remodelling.

II. Conclusion

Various surgical techniques have shown promising results with regards to the acceleration of tooth movement. MOPs, however, are proving to be a minimally invasive, repeatable, relatively easily administered minor surgical procedure which can be done using normally available orthodontic appliances.

Patients have reported very mild and insignificant discomfort and pain after receiving MOPs as compared with those who undergo conventional orthodontic treatment procedures indicating that patient compliance is high with this procedure.

A way forward to further assess the effectiveness of MOPs and whether they actually accelerate the overall treatment time of orthodontic therapy includes conducting clinical trials for longer durations of time, preferably till the end of the treatment period completely. Also, the recruitment and follow-up of larger sample sizes is highly recommended.