Efficiency of Micro-osteoperforations for Accelerating Posterior Intrusion Using Skeletal Anchorage Unit

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By:

Lobna Adel Aly Elmy Shalaby

B.D.S, Faculty of Dentistry, Ain Shams University, 2001

M.D.S, Faculty of Dentistry, Ain Shams University, 2010

Supervisors

Dr.Khaled Mostafa Fawzy

Professor of Orthodontics

Faculty of Dentistry, Ain Shams University

Dr. Islam Tarek Hassan

Assistant Professor of Orthodontics

Faculty of Dentistry, Ain Shams University

Dr. Ibrahim Mazen Negm

Lecturer of Orthodontics

Faculty of Dentistry, Ain Shams University

Dr. Ashraf Mohamed Abd El Rahman Abu-Seida

Professor of Surgery, Anesthesiology & Radiology

Faculty of Veterinary, Cairo University

Faculty of Dentistry

Ain Shams University

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Introduction

Skeletal anterior open bite is considered one of the most challenging malocclusion especially in adult patients. These cases are usually associated with skeletal features in the form of increased mandibular plane angle, anterior face height, and maxillary posterior dentoalveolar structure. It is necessary to redirect maxillary growth with molar intrusion, to rotate the mandible in an upward and forward direction.

There are different treatment modalities according to the age, etiology as well as the associated dentoalveolar deformity. In growing cases, the main aim of early treatment is eliminating the etiology, using habit breaking appliances, to reduce its adverse effect on growth and intercept the developing malocclusion. Treatment often requires redirecting and controlling hyperdivergent growth pattern. This could be achieved by depressing the posterior teeth with a high-pull headgear, repelling- magnet splints and posterior bite blocks[1]. Other treatment options are directed towards controlling the backward rotation of the mandible using vertical-pull chin cup separately, or in conjunction with fixed orthodontic therapy.

However, in adults treatment options could be divided into two main categories, camouflage orthodontic treatment and orthognathic surgery. The first category is performed by different treatment options as extrusion of anterior teeth, extraction of posterior teeth or intrusion of posterior teeth. When an intrusive force is placed on a molar using conventional orthodontic mechanics, the reactive force of extrusion, which occurs predominantly on the premolars, can virtually cancel out the molar intrusion.

Orthgnathic surgery includes repositioning of the maxilla or the mandible. This could be achieved by Le-Fort 1 osteotomy with maxillary impaction to achieve reduction of anterior facial height.

The complexity, risk, and cost of surgical treatment as well as the biomechanical limitations of molar intrusion with the conventional orthodontic appliance have stimulated a search for alternative clinical procedures.

Recently, different skeletal anchorage system in the form of miniscrew implants, and miniplates have been used to facilitate and allow the achievement of a wider range of orthodontic movements successfully. Molar intrusion with skeletal anchorage has now become a strategy for

treating these patients owing to the ideal force system delivered without side effects. Among the various types of implants, orthodontic microscrews are widely used because of their ease of placement and relatively comfortable surgical procedure[2].

Lately, the pace of life as well as the highly social demands is clearly reflected on orthodontic patients in the form of increased request for faster orthodontic treatment without any compromise in the final treatment results.

Several modalities have been reported to accelerate orthodontic tooth movement such as low-level laser therapy, pulsed electromagnetic fields, electric currents, corticotomy, dentoalveolar or periodontal distractors[3].

It has been shown that combination of orthodontic treatment and surgical alveolar corticotomies were effective in accelerating orthodontic tooth movement[4]. This technique demands full thickness flap reflection with extensive decortications which in turn would increase cellular activity and stimulation of differentiation of osteoclast from circulating precursors.

This technique has little acceptance among patients due to its highly aggressive nature. For this reason corticision was introduced as a less aggressive alternative to create cortical activation. A cortical incision was made by malleting a reinforced scalpel to separate the interproximal cortices transmucosally. It was found that this technique induced regional acceleratory phenomenon effect which fastened tooth movement.

The fear of repeated malleting led to the suggestion of “piezocision “, in which an ultrasonic piezosurgical tool was used to perform the incisions[4]. This procedure is a minimally invasive procedure that combines both microincisions and localized piezoelectric surgery without flap elevation[5].

Since molar intrusion is considered a time consuming type of tooth movement, therefore this inspired the idea of this study in which molar intrusion will be combined with minimally invasive microosteoperforations in cortical bone to increase the efficiency of this treatment protocol.

Review of literature

Open bite Treatment Modalities for Adult Patients

Choosing the best treatment option for open bite treatment has been investigated in many previous studies.

Comparison between the treatment outcome of severe open bite cases in adults using skeletal anchorage and orthognathic surgery has been explored by Shingo Kuroda et al. The sample consisted of twenty-three subjects which were divided into two groups. Ten cases were treated with skeletal anchorage (n=10) while the rest were treated with LeFort I osteotomy combined with mandibular osteotomy (n=13). There were no significant differences in the treatment results between skeletal anchorage and surgery, with reduced facial heights of 4.0 and 3.8 mm, and increased overbites of 6.8 and 7.0 mm, respectively. On the other hand incisors were significantly elongated in the surgically treated subjects (4.6 mm). These results suggested that molar intrusion with skeletal anchorage is simpler and more useful than 2-jaw surgery in the treatment of patients with severe anterior open bite[6].

Another study was conducted to compare between orthodontic treatments outcomes in adults with skeletal open bite using conventional edgewise treatment and implant-anchored orthodontics. A sample of thirty adults was divided equally into two groups, 15 for non implant treatment [non-IA group] and 15 for implant-anchored treatment [IA group]. Treatment outcomes were assessed using cephalometric analysis, peer assessment rating, discrepancy index, and objective grading system. The results showed that open bite was mainly corrected in the non IA group with 3 mm of maxillary incisor extrusion and 2 mm of mandibular incisor extrusion. On the other hand, the IA group showed intrusion of the maxillary and mandibular molars which resulted in counterclockwise rotation of the mandible. Furthermore, in the IA group, the soft-tissue analysis showed decreases in the facial convexity. They concluded that Ideal occlusion could be achieved in adults with severe open bite with both conventional edgewise and implant anchored orthodontic treatment. However, absolute intrusion of the molars and improvement in esthetics might be achieved more effectively by using miniscrews as an anchorage device [7].

Molar Intrusion using skeletal anchorage

Using zygomatic anchorage in the form of miniplate in the infrazygomatic crest of the maxilla was introduced to perform en masse impaction of the posterior segment without any side effects. A 14-year-old, female Class II patient with an anterior open bite was treated with a new generation posterior intrusion appliance. At the end of treatment, a Class I canine and molar relationship and a correction of the anterior open bite were achieved. The molars were impacted 3.6 mm, and this impaction was maintained throughout the treatment. The mandibular plane showed a counterclockwise autorotation of 4 degrees [8].

The dentoalveolar and skeletal effect of posterior segment intrusion was investigated. A study was conducted on 11 subjects (5 males and 6 females) with a mean age of 19.5 years. Intrusion of the posterior dentoalveolar segment was performed using an intrusion appliance supported by bilateral zygomatic implants (two I-shaped multipurpose zygomatic miniplates) . The intrusion appliance consisted of two shallow acrylic bite blocks, connected to two heavy palatal arches (1.4-mm round stainless steel) and wire attachments on each buccal side for force application. The bite blocks covered all the teeth that needed to be intruded. Two 9-mm NiTi coil springs were placed bilaterally between the tip of the miniplate and the outer wire, which created an intrusive force of 400 gm. Lateral cephalograms were taken for each subject before treatment (T1) and at T2, which is defined as the time point at which the intrusion was completed. The mean intrusion time was 9.6 months. The mean intrusion measured as the distance of the U6 to the palatal plane was 3.6 and the overjet was reduced by 1.4 mm. The study concluded that zygomatic anchorage could be used effectively for open-bite correction through posterior dentoalveolar intrusion[9].

Using combined treatment in the form of corticotomy with skeletal anchorage in open bite treatment was introduced in a study which was performed to distinguish the effect of this combined treatment. Ten adult patients (15 to 25 years) received combined subapical corticotomy and intrusion forces of 200 to 300 g were applied on the attachments of each molar and both premolars. For molar and premolar intrusion, two buccal miniplates and two palatal minisrews were inserted bilaterally. Intrusion force was applied for a period of 12 to 15 weeks. Open bite

was successfully corrected with significant intrusion of maxillary posterior teeth which provided counterclockwise rotation of the mandible. They concluded that this technique could be used an alternative method for skeletal open bite correction in adults who reject orthognathic surgery[10].

Ideal Sites for Placement of miniscrew implants

The site of placement of miniscrew implant in the infrazygomatic (IZ) creat of maxilla has been investigated in a previous study. This study used computed topographic images to measure the thickness of the infrazygomatic (IZ) crest above the maxillary first molar at different angles and positions to the maxillary occlusal plane. The results showed that the IZ crest thickness ranged from 5.2 mm to 8.8 mm, measured at 40° to 75° to the maxillary occlusal plane and 13 to 17 mm above the maxillary occlusal plane. It concluded that miniscrew placement in the IZ crest of an adult should be inserted 14 to 16 mm above the maxillary occlusal plane and the maxillary first molar at an angle of 55° to 70° to the maxillary occlusal plane[11].

A study was performed to determine palatal bone density in adults in order to help in selecting the most suitable miniscrew implant site. This study used Computed tomographic (CT) images of 30 adult subjects (15 males and 15 females) with ages ranging from 23 to 35 years. Bone density was measured in Hounsfield units (HU) at regular mediolateral and anteroposterior intervals along the midpalatal suture. The results showed that there was a great range of bone densities (805 to 1247 HU) according to the different sites. There was significant difference between male and female subjects. The more the implant is placed posterior and lateral in the palate, the less the bone density. On the other hand, the midpalatal area within 3 mm of the midsagittal suture showed the densest bone in the entire palate. It was concluded that mini-implants could be effectively placed in most areas of the palate if they are placed from 3 mm posterior to the incisive foramen and 1 to 5 mm to the paramedian side[12].

Cortical bone thickness at common miniscrew implant placement sites was measured using Cone beam computed tomography images; a study was performed to assess age, sex and regional differences at different sites in both the maxilla and the mandible. The sample consisted of 52 patients (26 adolescents and 26 adults). Cortical bone thickness was measured at 16 sites. The results showed that there were significant differences between adolescents and adults.

Anterior paramedian palatal bone was significantly thicker than posteriorly located one. The mandibular buccal and infrazygomatic crest regions had the thickest cortical bone. There was no sex differences in cortical bone thickness at sites commonly used for MSI placement[13].

Micro-Osteoperforation

Recently, a new minimally invasive technique, piezopuncture, was developed for accelerating tooth movement. A study was performed on 10 beagle dogs which were divided into two groups. In the experimental group, a piezotome was used to make cortical punctures through the gingival around the moving teeth. The results showed that this technique significantly accelerated tooth movement, with the maximum acceleration during the first two weeks for the maxilla and the second week for the mandible[5].

The effect of micro-osteoperforations on the rate of tooth movement and the expression of inflammatory markers was studies in a randomized clinical study. It was performed on twenty adults with Class II Division 1 malocclusion who were divided into control and experimental groups. In the experimental group three small micro-osteoperforations were performed in the extraction space at equal distances from the canine and the second premolar. Each perforation was 1.5 mm wide and 2 to 3 mm deep. A handheld appliance designed by Propel Orthodontics (Ossining, NY) was used for performing MOPs. The result showed that micro-osteoperforations significantly increased the rate of tooth movement by 2.3-fold; and a significant increase in the levels of inflammatory markers was also observed [14].

Methods of Investigation of molar intrusion

In a previously mentioned study performed to evaluate the dentoalveolar and skeletal effects of the new-generation open-bite appliance, lateral cephalograms of the subjects were taken before treatment and after intrusion. Eight angular and seven linear cephalometric measurements were determined. The mean intrusion was measured as the distance of the U6 to the palatal plane, which was 3.6 mm. This resulted in an average of 3degrees of closure of the Go-Gn-SN angle. The gain in the overbite was 5.1mm, and the overjet was reduced by 1.4 mm.

The change in the occlusal plane angle was an average of 2.4 degrees of counterclockwise rotation. The lower facial height was also decreased significantly by 2.9 mm [9].

Another study was undergone to validate true intrusion of molars in adults using miniplates as anchorage for intruding posterior teeth in the maxilla. Four adults (2 men and 2 women) were selected with long-standing open bites and no habit history. A Burstone analysis of each patient's lateral cephalometric radiograph was performed to determine whether the maxilla or the mandible had posterior vertical dentoalveolar hyperplasia associated with the anterior open bite. In this study, panoramic radiographs were used to assess treatment results claiming that there was no overlap of images of the contralateral side as with a lateral cephalogram. They mentioned that it provided the most easily discernible images for identification, location, and measurement because they show the entire treated dental segment, alveoli, and miniplates on each side. Molar intrusion was determined by measuring the vertical distances between miniplate and molar band[15].

Recently, Cone-beam computerized tomography (CBCT) is used for more accurate 3D evaluation and measurements of the magnitude and direction of molar intrusion thus matching the new orthodontic paradigm.

An article was performed to describe a goal-oriented strategy for nonsurgical correction of skeletal Class II open bite in an adult patient using the SAS, with the results evaluated by cone-beam computed tomography (CBCT). A 39-year-old female patient was treated using miniplates in the maxilla and the mandible in order to intrude the upper molars 3mm, and to distalize the upper and lower molars 5mm and 2mm, respectively. Individualized treatment goals were established with cephalometric and occlusogram predictions before treatment. Post-treatment CBCT images clearly showed both superior and distal movement of the upper molars. The upper first and second molars had penetrated into the sinus after intrusion, and the mucous membranes had thickened significantly. There was slight root resorption of the first and second molars, but it was not considered clinically significant[16].

Aim of the study

The aim of this study is to assess the efficiency of micro-osteoperforation for accelerating posterior intrusion in open bite cases.

Materials and Method

The research will be conducted on two separate samples, a human study and an animal sample.

Human Study:

1. Sample

- This study will be conducted on a sample of thirty subjects from the out-patient clinic of Orthodontic Department, Faculty of Oral and Dental Medicine, Ain Shams University.

  Inclusion criteria:

1. Non growing postpubertal adolescent and adult patients as verified by cervical vertebrae maturation index ranging from 17 to 29 years.

2. All patients with skeletal open bite as confirmed from cephalometric measurements.

Exclusion criteria:

1. Patients suffering from any systemic diseases or congenital anomalies affecting bone.
2. Patients who already had previous orthodontic treatment.

2. Method

An informed consent will be signed by the patients before their enrollment in the current study in which the aim of the study, the methodology and possible complications will be clearly described. This research will be reviewed by research ethics committee, Faculty of dentistry, Ain Shams University.

The sample will be randomly divided into two groups, Group I (GI) and Group II (GII). In group I, micro-osteoperforations will be performed bilaterally followed by miniscrew implant placement and molar intrusion. In group II, molar intrusion will be performed using the same skeletal anchorage assembly without any cortical perforations.

Appliance Design:

In both groups, a thin acrylic bite block will be placed bilaterally covering the occlusal surface of the posterior segment with buccal and palatal hooks (buttons) .Those hooks will be used later as a mean for attachment of Nickel- Titanium closed- coil springs.

Group I:
Surgical procedure:

1. Local infiteration anesthesia (Mepecaine-L) will be injected in the buccal vestibule, apical to the roots.
2. Micro-osteoperforations will be performed using Propel Ecellerator device to perform the cortical perforations penetrating the gingiva.
3. The depth of cortical injury will range from 3 to 7 mm.
4. Cortical perforations will be performed on both the mesial and distal interproximal areas of the teeth to be intruded starting 2 to 3 mm apical to the alveolar crest and extending 2 to 3 mm past the estimated root apices which will be measured using a periapical radiograph taken by the paralleling technique. Horizontal perforations will be performed connecting the interdental ones.

For both Groups Temporary anchorage device (TAD) in the form of miniscrew implants will be used as a mean of anchorage

Buccal Miniscrew

1. Local infilteration anesthesia (Mepecaine-L) will be delivered to the buccal mucosa at the depth of the vestibule at the area related to the first and second molars
2. Miniscrew implant (ranging from 1.6 to 2 mm in diameter and from 8 to 12 mm in length) will be delivered bilaterally to the infra-zygomatic crest of maxilla.
3. A ligature wire will be ligated to the buccal miniscrew head and tied into a pigtail. The end of the pigtail ligature wire will be bent to form a hook in order to facilitate attachment of the coil springs.

Palatal Miniscrew

1. At the same visit, local infilteration anesthesia (Mepecaine-L) will be delivered to the palatal mucosa
2. A palatal miniscrew implant (ranging from 1.6 to 2 mm in diameter and from 8 to 10 mm in length) will be inserted bilaterally.
3. Antroposteriorly, it will be positioned apical to the first molars.
4. Mediolaterally it will be placed at the area of thickest amount of bone which was usually found to be at the intersection between the two slopes of the hard palate.

Patients will be instructed to follow strict oral hygiene measures especially at implant sites and rinse with saline for one week after implant insertion to avoid any inflammation around the miniscrews during the observation period.

Loading the Miniscrew:

1. Immediate loading of the miniscrews will be performed through Nickel- Titanium closed- coil springs attached between the hooks and the miniscrews both on the buccal and palatal surfaces on both sides.
2. A tension gauge will be just to measure the force delivered by the closing coil spring and a force ranging from 150 to 200 grams will be exerted from both the buccal and palatal sides bilaterally, so that the total force exerted on each molar would range from 300 to 400 grams.

3. Evaluation of treatment results

Records:

The following records will be taken:

1- Orthodontic study casts; before treatment, at an interval of four weeks during intrusion, and after finishing intrusion.

2- Lateral cephalometric radiographs pre and post-treatment.
3- Cone beam computed tomography; after miniscrew implant placement and after finishing intrusion.
4- Extra and intraoral Photographs before treatment and after finishing intrusion.

Animal Experiment:

Sample:

The study will be performed on a sample of ten mature mongrel dogs of comparable weight (15 to 25 Kg). Dogs will be kept in the animal house of Faculty of Veterinary Medicine, Cairo University, under the supervision of Professor: Ashraf Abu- Seida.

Each dog will be kept in a separate cage. Dogs will be fed on protein rich diet during the study, and will be kept in well ventilated rooms.

Split- mouth technique will be used. Buccal and palatal miniscrew implants will be placed bilaterally between the maxillary molars. Micro-osteoperforations will be performed unilaterally (experimental side). On the other side, molar intrusion will be performed using the same skeletal anchorage assembly without any cortical perforations (control side).

Microsteoperforation Surgery:

A Propel Ecellerator Device will be used to perform the cortical perforations penetrating the gingiva. The depth of cortical injury will range from 3 to 7 mm.

Cortical perforations will be performed on both the mesial and distal interproximal areas of the maxillary molars starting 2 to 3 mm apical to the alveolar crest and extending 2 to 3 mm past the estimated root apices. Horizontal perforations will be performed connecting the interdental ones.

Loading the Miniscrew:

A thin acrylic bite block will be performed bilaterally covering the occlusal surface of the posterior segment with buccal and palatal hooks (buttons) .Those hooks will be used as a mean for attachment of Nickel- Titanium closed- coil springs.

Immediate loading of the miniscrews will be performed through Nickel- Titanium closed- coil springs attached between the hooks and the miniscrews both on the buccal and palatal surfaces on both sides.

During the observation period, animals will be given oral Carprofen (at a dose of 4mg/kg once daily) as an analgesic to control pain.

At the end of the observation period, animals will be scarified following the standard operating procedures of animal house by I/V administration of anaesthetic overdose (Thiopental). Carcasses and wastes of the used animals will be hygienically disposed by burning (incinerator).

Evaluation Methods:

For the histologic procedures, two dogs will be sacrificed after 1, 2, 3, 4 and 8 weeks of force loading. Each maxilla will be dissected free, and soft tissue will be immediately removed. The maxillary segments will be dissected. The sections will be stained with hematoxylin and eosin for routine examination.

These records will be analyzed statistically for treatment effects using the following tests:

- Discreptive statistics including minimum , maximum, mean, standard deviation (SD) and standard error (SE) values will be calculated for each group.
- Kolmogorov-Smirnov test will be used to test the normality of the obtained data.
- One-way Analysis of Variance (ANOVA) will be used to compare between the testing groups.

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