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Clinical Assessment of Posterior Mandibular Orthodontic Miniplates Fixation with 6-mm Miniscrews

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□ ABSTRACT □

This study aims at assessing the clinical success of Y-shape miniplate as orthodontic anchorage, the safety of using 6-mm self-drilling fixation miniscrews (FMSs), and patients' postoperative complications. A total of 26 consecutive patients and 52 Y-shaped miniplates in the both sides of the mandibule were enrolled. The miniplates were fixed in place with 116 self-drilling FMSs. During healing period, the heath of adjacent teeth and inferior alveolar nerve were evaluated, and any related complication was recorded. There was no evidence to suggest inferior alveolar nerve or adjacent tooth disturbance during or after placement of the miniplates. No miniplate failed before the end of treatment (0% failure rate). Only one case with acute infection was successfully treated and the miniplate was not removed and remained stable during orthodontic loading. No chronic inflammation with tissue proliferation around the miniplate in any miniplate. Mandibular orthodontic miniplate fixated with 6-mm FMSs in the area between the first and second molars has a high success rate with few side effects or complications affect adjacent roots or the inferior alveolar nerve.

Keywords: miniplate, miniscrew, mandibule .

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تقييم سريري للصفائح التقويمية الموضوعة في المنطقة الخلفية من الفك السفلي والمثبتة ببراغي طول 6 ملم

الدكتور سامر قصبة*

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هدفت هذه الدراسة إلى تقييم نجاح استخدام الصفائح التقويمية ذات الشكل حرف Y كدعائم تقويمية، ومدى أمان استعمال براغي التثبيت ذاتية الإدخال بطول 6 ملم في المنطقة بين الرحتين السفليتين الأولى والثانية، والاختلاطات الناتجة عن استعمالها. تمت الدراسة على 26 مريض خضعوا لعمليات تثبيت 52 صفيحة تقويمية في طرفي الفك السفلي. تم تثبيت الصفائح باستخدام 116 برغي تثبيت. خلال فترة الشفاء تم تحري سلامة كلاً من الأسنان المجاورة والعصب السني السفلي، وتسجيل أي اختلاط ناتج عن المعالجة. لم يوجد أي دليل على تأذي أي من الأسنان أو العصب السني السفلي خلال وبعد وضع الصفائح. لم تفشل أي صفيحة قبل نهاية مدة المعالجة (نسبة فشل 0 %). حدثت فقط حالة واحدة لالتهاب حاد تم معالجته بنجاح ولم يتم إزالة الصفيحة لأنها بقيت ثابتة خلال فترة التحميل التقويمي. لم يتم تسجيل أي حالة التهاب نسج رخوة مزمن تكاثري حول الصفائح. يترافق وضع الصفائح التقويمية المثبتة ببراغي طول 6 ملم بين الرحتين الأولى والثانية السفلية بنسبة نجاح عالية مع عدد قليل جداً من الاختلاطات خاصة فيما يتعلق بالأسنان المجاورة أو العصب السني السفلي.

الكلمات المفتاحية: الصفائح التقويمية، البراغي التقويمية، الفك السفلي .

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Introduction :

Recently, as a result of advances in biocompatible medical materials, titanium miniplates and fixation miniscrews (FMSs) have long been used successfully in maxillofacial surgery for orthognathics, trauma reconstruction, and osseous stabilization. Their application for anchorage in orthodontic treatment is relatively new but has been used with acceptance and success for a variety of orthodontic anchorage needs because they permit the orthodontist to treat certain malocclusions that are impossible to be managed with traditional methods.[1]

In general, most commercially available titanium miniplates used in orthognathic surgery are suitable for orthodontic anchorage. However, several manufacturers produce orthodontic miniplates that come in a variety of shapes and sizes. The surgeon must have an assortment of lengths and shapes to meet the needs of the patient and the treatment plan designed by the orthodontist. The miniplate must be long enough to be out the root region and allow at least the last loop on the plate to project transmucosally into the buccal vestibule. The orthodontist uses this last loop on the miniplate to attach an elastic thread or other device to the bands or brackets on posterior teeth.[2]

Jenner and Fitzpatrick [3] first reported the use of an osteotomy mini-plate for orthodontic anchorage in 1985. The use of miniplates for orthodontic anchorage was initially conceived with the purpose of accomplishing lower molar distalization [4]. Eventually, however, Umemori et al.[1] developed a skeletal anchorage system (SAS) using a titanium miniplate to assist in correcting skeletal open-bite deformities in adult patients. The miniplate design has been modified and developed by Sugawara et al.[2] to act as a hook, whereas De Clerck and Cornelis [5] modified it as Ballard miniplate. Chung et al.[6] designed a 0.036-in diameter tube by curving the end of a titanium miniplate, called the C-tube.

Miniplate advantages can be summarized in that they simplifies complex treatments and permits correction of malocclusions previously thought beyond the scope of orthodontic therapy alone; and may provide more sufficient stability and secure anchorage to resist orthodontic forces when orthopedic forces are needed; and do not interfere with dental movements because of the fact that their fixation FMS are generally placed apical to the roots; and do not rely on patient cooperation, except for the usual hygiene and maintenance of the orthodontic appliance. Moreover, they are well tolerated by the patients and easy to be placed by doctors, and they are superior from the social and esthetic points of view, when compared with other conventional devices, with high success rates. However, miniplates feature certain disadvantages in relation to conventional devices, such as the need for more invasive insertion and removal surgeries, do that, the miniplates should be placed by a surgeon; the relatively high cost; the difficulty of maintaining oral hygiene around the miniplate; and the increased likelihood of infection and discomfort in the first days.[7,6,8,9]

Although there have been promising studies, there are few studies on the post-treatment complications of miniplates used for orthodontic anchorage. It was reported that osteosynthesis miniplate can injure the adjacent dental roots and inferior alveolar nerve.[10,11] According to our knowledge, there are no scientific assessments of either the frequency of 6-mm length FMSs and root proximity, root penetration, and inferior alveolar nerve involvement after orthodontic miniplate placement; or the effectiveness and complications of the use of Y-shape miniplate.

The purpose of this article is to view our results with the use of Y-shaped mandibular orthodontic miniplate, and to assess the safety of the use of 6-mm self-drilling FMSs on

adjacent anatomic structures between the first and second molar. The surgical technique with important surgical parameters necessary for miniplate success will be discussed.

Materials & Methods :

A total of 26 consecutive patients with malocclusions (14 males, 12 females, mean age 12±1 years) requiring skeletal anchorage for orthodontic treatment who had undergone orthodontic treatment using orthodontic miniplate in both the upper and lower jaws were included in this retrospective study. All the patients were treated in the Faculty of Dentistry, Damascus University, Syria during 2011.

Fifty-two Y-shaped titanium miniplates for orthodontic Anchorage (AP-YL-013& AP-YR-013, Jeil Medical Co.) (Figure. 1) were used in the both sides of the mandibule of these patients.

Figure 1. Y-shaped miniplate for right side (Y-R) and left side (Y-L).

The miniplates were fixed in place with 116 self-drilling FMSs (diameter 2-mm, length 6-mm) with a head designed to be seated within the thickness of the miniplate after placement.

The ideal position for miniplates insertion was evaluated by using a panoramic radiograph in order to avoid damage to the roots of the adjacent teeth and mandibular nerve. Miniplates surgical placement was carried out according to the following protocol:

All surgeries were performed under infiltration local anesthesia. A buccal incision from the distal of the second molar to the mesial of the first molar was made2-mm apically to the mucogingival attachment. The mucoperiosteal flap was then elevated for cortical bone to expose at the apical region of this area.

The miniplate was adapted to the bone surface at the apical region between the first and second molar mainly according to the orthodontist consultation concerning the appropriate emergence of the exposed loop sagittally, vertically, and transversely. The Y-shaped miniplate helps in positioning the central hole and one of the two other lateral holes in vertical relationship in the area between the first and second molars.

The miniplates were fixed to the buccal cortical bone with the self-drilling FMSs, with the arm exposed to the oral cavity from the incised wound. The first FMS was not completely seated to allow some adjustment of the miniplate to an ideal position before placement of the another/other FMSs. All FMSs were subsequently tightened with a hand driver without torque control. Randomly, three FMSs were used to fix the miniplate passively in only three miniplates, while the rest of miniplates were fixed with only two FMSs. We confirmed that the miniplate did not disturb mandibular movement (Figure. 2).

Figure 2. Placement of a titanium miniplate. Surgical procedure with 2 or 3 fixation miniscrews.

The incisions were primarily closed around the miniplate plane with 3-0 silk sutures, ensuring that the occlusal loop was cleanly exposed above the wound margin.

We operated only one side each visit, s o a period of two weeks in the right side and three weeks in the left was allowed for wound healing before application of force to the miniplates.

During and after this period, special hygienic care was taken. The patients were instructed in how to clean the peripheral region of the miniplates and 0.12% clorexidine gluconate mouth rinses were recommended. Antibiotics and nonsteroidal anti-inflammatory were prescribed for 5 days after miniplate placement, and analgesia was described only when it was necessary.

The clinical condition of all the patients was evaluated first at the appointment for suture removal (a week after surgery), where a surgeon explored the wound for closure and recorded any complication. The evaluation was repeated during orthodontic treatment for at least 9 months.

The mandibular molar shealth was assessed using percussion test. The inferior alveolar nerve function was assessed using its neurosensory in the mental area. All patients were specifically questioned about their chin and lip sensibility (experience any of the following: numbness, pain, tingling) for subjective assessment. When the event of any sensory impairment would be detected, the affected area was planned to be mapped and two objective tests (2-point discrimination and light touch tests) would be used for assessing. All the subjective and objective neurosensory measurements were categorized into two classes: normal and abnormal.

Assessment of miniplate mobility was performed using the scale used by Choi et al.[12] as follows: 0, no movement; 1, ≤ 1-mm of movement; 2, >1-mm of movement. An infection was defined as a purulent discharge from the peri-miniplate mucosa or a closed swelling requiring an incision and drainage of the pus. Chronic inflammation was considered when an inflammation with tissue proliferation around the miniplate. Pain and swelling were recorded as complications when they were prolonged or severe and required medications to be released. Time of suffering these complications was also recorded. Visual Analog Scale (VAS) was used for pain evaluation.

Results & Discussion :

According to the subjective test of the inferior alveolar nerve function, all patients reported the function to be normal, so no objective tests were performed. There was no evidence to suggest tooth or periodontal ligament disturbance (pain, loss of vitality, sensitivity on percussion) during or after placement of the miniplates.

The post-treatment clinical examination showed no miniplate failed before the end of treatment (0% failure rate). The post-treatment clinical examination showed only one case

with acute infection in a male caused by bad oral hygiene surrounding the miniplate that was referred to a patient's fear of cleaning the area. However, the infection was successfully treated and the miniplate was not removed and remained stable during orthodontic loading. No chronic inflammation with tissue proliferation around the miniplate in any miniplate. Cheek irritation was reported problem by three patients, but for none of them this was considered severe enough to require removal of the miniplate.

Almost all patients felt well after surgery and during the orthodontic treatment period. No patient had intense pain during miniplates placement. No patient reported the need for additional pain killer than was prescribed to control the pain. At the suture removing appointment, no patient continued to report pain. The post-operative period of miniplate insertion characterized by minor edema requiring no additional medication to be resolved.

Many patients experienced persistent difficulties in cleaning their miniplate. Precise recommendations for careful brushing of the miniplate and surrounding mucosa with a soft toothbrush were repeated when it was necessary.

Understanding mandibular morphology is critical to avoid complications in an otherwise simple surgical procedure. When using miniplates, several factors play an important role in the safe and successful use, and should be considered as anatomical guidelines in an effort to minimize the complications. Those factors are the quantity of mandibular cortical bone and its relationship with the position of the inferior alveolar nerve, the mandibular molar root surface and apex, and the characteristics of the surrounding mucous membrane. Other surgical issues include the surgical incision position, FMS properties and insertion technique, and the postoperative care.

Anatomic Factors :

a. Thickness of Buccal Posterior Cortical Bone :

More recently, an interest in cortical bone thickness and quality has developed in conjunction with orthodontic skeletal anchorage systems.[13,14,15,16] From a clinical standpoint, the thickness of the buccal cortical plates hold important clinical implications.[17,18,19,20] From the literature, the thickness of buccal cortical bone has relation with the sites, age, sex, mandibular plane angle, and the growth facial pattern.

Sites: Different studies showed that differences in cortical bone thickness were evident between sites in the various mandibular regions.[13,14,15,16,21,22] Thickest cortical plates were found at the molars (average cortical bone thicknesses ranged from 1.59- to 3.2-mm) and became progressively thinner anteriorly, and increased gradually in the apical direction. Moreover, it was shown that there are no differences in cortical thickness between sides of the jaws.[23,24,15] However, different results were reported in only few studies where no significant difference between different locations according to the distance from the alveolar crest at the occlusal and apical levels, and the average cortical thickness increased from 1.4-mm in the posterior areas to 3.7-mm anteriorly.[24]

Age: Even though, no age-related difference was reported in cortical thickness distal to the mandibular first molar, a variability of the buccal cortical thickness between subjects was significant in different studies.[25,17,26] It was clearly showed that adult cortical bone is usually thicker than adolescent bone especially mesial to the mandibular first molar.[27,17,26] More particularly, in Swasty et al'. study,[25] the subjects who are 10 to 19 years old have thinner cortical bone, the mandible has not fully reached peak thickness until the 20- to 29-year-old range, and it continues to mature through 40 to 49 years of age, then it decreases in thickness after this period. When placing miniplates in growing

patients for long period, a significant amount of bone remodeling could occur; which might explain the higher failure rate due to mobility in growing patients than in adults.[28]

Sex: Animal experiments have demonstrated that the determinant cortical bone thickness has relation with the functional capacity,[29,30] then sex differences might be expected because males have larger bite forces and masticatory muscles than do females.[31,32,33,34] This was confirmed by several studies where males had a significantly thicker buccolingual dimension and buccal cortical thickness than females in both the maxilla and the mandible.[27,17,35] Other studies found no sex differences in cortical thickness for the mandible.[26,23,17,34]

Mandibular plane angle: According to some studies, the thickness of buccal cortical bone in subjects with a high mandibular plane angle, i.e. the opening of the mandibular angle, was thinner than that in subjects with a low angle in the mandibular first molar region.[36,37,9]

The growth facial pattern: It was shown that the growth facial pattern has an influence on the morphology of labial/buccal and lingual bone plates. Regarding the thickness of the buccal and lingual bone plates, the difference between hypodivergent and hyperdivergent patients seems to be restricted to the level of the root apex. The thickness of the bone plates at the level of cervical and middle thirds of the root is very similar indifferent facial patterns. However, the distance from the root apex to the external surface of buccal and lingual cortical bone is greater in hypodivergent patients compared to hyperdivergent patients.[36]

b. Buccal Aspect of the Nerve from the Buccal Cortical Margin of the Mandible

The mandibular nervecourse was described to follow an "S-shaped". It is located in the buccolingual dimension either in contact with or close to the lingual cortical plate (≤ 2-mm) in the molar region of the majority of the cases. The nerve then crosses back to a more buccal position beneath the apex of the second premolar.[38,39,40] This supports the results of this and other studies since the greatest distance between the cortical plate and the mandibular nerve was at the level of the first and second molars (4.9-mm).[41,42,43]

c. Interradicular Spaces

In experience with miniscrews might be applicable with less importance to MFSs, Poggio et al.[13] provided an anatomical map to assist the clinician in miniscrewplacement in a safe location between dental roots.They found the interradicular spaces between the second and first molar (the mean and the standard deviation of mesio distal measurements where 4.7 mm) to be one ofthe safer sites availablein the posterior mandibule.

No data are available on how much bone is necessary between the FMS and the dental roots for both periodontal health and FMS stability. Considering that the width of periodontal ligament is approximately 0.25-mm, Poggio et al.[13] assume that a minimum clearance of 1-mm of alveolar bone around the miniscrew could be sufficient for periodontal health. A 2-mm diameter could be considered safe if at least 4-mm of space are available in the interradicular space.[44] This might be considered as anadditional safe factors in our study, even though the length of the FMSswas sufficient enough to be placed is the area between the distal rooth of the first molar and the mesial root of the second molar.

Taking in consider the previously viewed literature review, and with the exception of some anatomical abnormalities, it might be believed that if we add the thickness of the miniplate, to the thickness of the buccal cortex between the first and second molar, to the space between the roots/mandibular nerve and buccal cortex at that area, and considering

the interradicular spaces between the first and second molar;it might be suggested that the full-depth placement of 6-mm FMS will place only 3-mm of the length in the cancellous bone, which hardly touch the lamina dura surrounding the tooth roots or the mandibular nerve.

Surgical Procedure :

Panoramic radiograph was the main pre- and post-operative diagnostic tool. It might be suggested that patients who require miniplate fixation should be subjected to a scan using computed tomography (CT) to reduce some of the potential complications. From our experience, this is particularly acceptable because the placement of the miniplate, as previously mentioned, is mainly controlled by the orthodontist preference, and the surgeon menuover range or preference is quite limited. However, if the miniplate successful placement is doubtful because of an expected complex anatomic environment, the use of CT scan becomes obligatory.[45]

The surgical placement was considered very easy to moderately easy by the surgeons and there seem to be a learning curve.[46] Local anesthesia block of the inferior alveolar nerve is commonly used technique eliminates all somatosensory perception of the mandible, mandibular teeth, floor of the mouth, ipsilateral tongue, and all but the lateral (buccal) gingiva. Generally, the surgeon desires these structures to be anesthetized. However, it was recommended that it may be useful for the patient to be able to sense when the inferior alveolar nerve is in danger of being damaged, so supraperiosteal infiltration anesthesia is a safe and effective method for posterior mandibular surgery.[47]

It was reported that miniplate arm whose emergences in the oral cavity surrounded by keratinized mucosa enables tight closure of the tissues that appeared to be necessary for good soft-tissue healing.[28,48,49,20] However, our surgical incision was located 2-mm apically to the mucogingival attachment because we believe that it is more difficult to place the arm penetrating the tissue at/above the mucogingival junction in younger patients, when alveolar height tends to be shallow, width of attached gingiva is less, and access is restricted.[28] However, the results of this study showed high success and less vulnerable to infection than was reported.[28,48,49,20]

Cheek irritation was reported as a frequent problem and for only 3 patients this was considered severe enough to require removal of the miniplate.[28] However, this complication was reported only in three patients of this study and the problem was successfully managed by minimal miniplate adaptation. This might be attributed to the miniplate design and the miniplate adaptation away from the cheek closer to the teeth.

The self-drilling FMSs used in this study were 6-mm long, even though they provided the required fixation of the miniplate, they also contributed to minimizing potential damage to adjacent roots. An animal data have shown that drill-free FMS insertion procedures have better success rates than drilling procedures.[50]

Haug [51] reported that the increased stability of miniplate fixation is obtained by increasing the number of FMSs from 2 to 3. In present study, similar success rate could be achieved by increasing the number of FMSs from 2 to 3 per miniplate, however, the small number of 3 FMSs group could not be considered statistically. Similarly, Choi et al.[12] found no significant statistical differences between the 2 types with respect to failure rate.

For patients who experienced increased mobility, FMS loosening was found during the postoperative period. The reason for the FMS loosening is not clear, but it might be due to insertion technique, force level, force duration, patient’s oral hygiene, thickness of cortical bones, or other factors.[28]

Y-shape miniplate was used in this study. According to our knowledge, this is the first study used this miniplate shape. Other miniplate shapes, such as L- and T-shaped, where used and there was no significant difference between the L- and T-shaped miniplates in mobility and infection rates.[12] However, we believe that the advantage of Y-shape miniplate over the other two shapes is that it enables the placement of two miniscrews in a vertical relationship, decreases their risks especially when the placement is within a limited safe area.

The period to wait before application of orthodontic forces in this study was two or three weeks, that was to allow the patient's soft tissues sufficient time to heal. This was advised by other studies although the application of orthodontic forces immediately after insertion is not ruled out.[4,1]

No failure in the mandibular miniplate was reported in this study, these results relatively agree with other reports where the success rate of miniplates was reported to be more than 80% in both maxilla and mandibule.[8,9,52,53,54,12,4,28,55] However, the results of present study is not in agreement with the results of some studies where titanium miniplates for orthodontic anchorage have a relatively higher failure rate when placed in the mandible.[12,54] No statistically significant difference in miniplate success was found between males and females in this study. This result agreed with those published by Choi et al.[12] even though they reported more complications in females than in males.

In this study, the FMSs placement was often undertaken in situations in which the exact position of the underlying tooth roots have not been exactly determined. Therefore, a FMS might be inadvertently placed into a periodontal ligament/root, even though this could not be confirmed using the percussion test. There is scant data in the literature addressing the consequences of tooth impingement. Borah & Ashmead [56] concluded, inadvertent tooth root impingement by osteosynthesis screws appears to have minimal adverse consequences. A human study by Maino et al.[58] confirmed that damaged root surfaces recovered well after removal of the FMS.

It was demonstrated that the inflammation and/or infection around the miniplate was due to an accumulation of bacterial plaque resulting from the patient's inadequate hygiene.[48,4] It was important in our practice to thoroughly educate patients to professionally clean the orally exposed part of the miniplates, which greatly reduces postoperative infection. In only one patient, although the miniplates were described as mobile throughout treatment, they were still sufficiently firm to provide the anchorage necessary to achieve the treatment objectives.[28]

We believe that this may have been responsible for the low incidence of infection and granulation rate in soft tissue surrounding the miniplates were seen in this study comparison with other previously reported studies where infection occurred in about 6-10% of patients,[12,58,54] inflammation rate in soft tissue surrounding was 7.6% [54], and the chronic inflammation occurred in 0.9% of patients.[58]

The surgical procedures, in this study, associated with minimal perioperative pain and inconvenience. Similar results were reported by other studies where no major recurring problems observed during treatment.[9,28,8,59]

The patients' chief complaint in other studies was swelling, which persisted on average for 5 days after surgery.[59,46] However, this was not the case with the results of this study, which might be as a result of relatively aggressive management of post-operative edema with anti-inflammatory agents and corticosteroids, the use of ice packs 1 to 2 hours postoperatively, and the patients completion with this recommendation.[46]

Conclusions & Recommendations :

The placement of mandibular miniplate with 6-mm FMSs in the area between the first and second molars can typically be performed with the patient under local anesthesia with few side effects or complications affect adjacent roots or the inferior alveolar nerve, and it may be considered a safe and effective adjunct for orthodontic treatment.

Because the findings are derived from a relatively small number of miniplates, we encourage further studies with more subjects such as different miniscrew and miniplate properties that identify better the factors might decrease the incidence of complications, and to determine standard guidelines for safe placement.

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