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Do Placement of Orthodontic Mini-Implants in Different Locations Improve Skeletal Effects in Herbst Appliance?

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1. Introduction

Since noncompliance of fixed appliances were introduced in Orthodontics, there has been a major improvement in the treatment of Class II cases. In the last couple of decades, some fixed devices, such as the Herbst appliance, were popularized to advance the mandible in the comprehensive Class II treatment. Herbst appliance causes an advanced mandibular positioning, creating both orthopedic changes in the condyle and fossa displacements. These changes reduce the overjet and achieve a molar and canine class I relationship. These devices, if not stabilized to OMIs (Orthodontic Mini Implants), may present adverse effects such as excessive inclination of the lower incisor and loss of lower molar anchorage. Maximum anchorage with OMIs located in the mandible minimizes or eliminates the mentioned side effects, creating new and more efficient protocols. Therefore, when forces are applied for orthopedic purposes, OMIs provide skeletal anchorage, although they are not always fully stable. Amongst stability factors that play an important key role are implants size and location, secondary stability, root proximity, bone density and cortical bone thickness. For instance, the stability of OMIs placed in the mandible may vary if the implants are located in the anterior or posterior part, due to the specific anatomical characteristics of these regions. Due to these parameters, mandibular OMIs in Herbst appliance could be placed in 2 sites: either interradicularly (IR) (between lower premolars) or in the external oblique line (EOL) also known as mandibular buccal shelf (MBS). This last position provides greater cortical bone thickness and allows bigger OMIs to improve stability.

2. Objectives

The objective of this study is to compare dental and skeletal effects in Herbst appliance treatment without anchorage, with interradicular skeletal anchorage and with skeletal anchorage in the external oblique line.

3. Materials and Methods

Forty-eight patients participated in this study. Class II skeletal malocclusion were treated with the same Herbst appliance in a period of 18-24 months. Data for the study was collected in Universitat Internacional de Catalunya. The patients were informed through a written consent, whereby they approved of their willingness to participate in this study. These patients were randomly divided into 2 groups for skeletal anchorage. The Herbst Group (n=19) with only dental anchorage was obtained from previous treatments and was selected as control group (CG); Two groups with skeletal anchorage were studied, one with OMIs located in External Oblique Line of mandible (EOLG) (n=10) and the other with OMI placed Interradicularly (IRG) (n=14). Patients' age was 12±1.9 in average. The mean treatment time with Herbst appliance was 10±1.7 months. Measurements were made at T1 - Immediately after Herbst appliance and OMIs placement and at T2 - Period of time of 1 month after Herbst appliance removal.

The measurements in this study consist in the inclination of the lower incisor related to mandibular plane (incisor mandibular plane angle IMPA, norm 90º± 2º), the sagittal discrepancy between the A-point (deepest point of the concave in the anterior maxilla) and B-point (deepest point of the concave in the anterior mandible) in the cephalometric Steiner values ANB discrepancy (norm 2º± 2º), and the Wits analysis discrepancy (norm 0±1mm) (drawing perpendiculars from A-point and B-point to the occlusal plane). The inclination measurements of the OMIs were done from the OMIŚs axis line to the mandibular plane line, before and after loading. This measuring methodology was used by several operators in longitudinal clinical studies on orthodontic mini-implants at the anterior- posterior and lateral-medial locations or longitudinal displacement, being a useful accuracy and reliability tool. Both OMIs were measured in this study by two different clinicians (indicated as MT1 and MT2 in table 1 and 2) in order to establish coefficient of correlation. The OMI that was measured and added to the statistic, was the one most visible in the X- ray.

In this study, inclusion criteria were: patients in age of growth between 10 and 14 years old with a cephalometric Steiner ANB range between +4º and +7º. The exclusion criterion in this study was the loss of mini- implants during the orthopedic treatment, extraction cases, breakage of the Herbst appliance more than 2 times in the same patient, previous lower incisor gum recession and patient with poor hygiene and gingivitis. The Herbst appliance (Herbst Developer HD, Tiger Dental, Bregenz, Austria) used for treatment was placed after bracket placement (MBT prescription) approximately 6 - 8 months after starting the orthodontic treatment. The brackets were placed to level and align the dental arches. Between the 3rd and 5th month of fixed appliance, OMIs were placed bilaterally in the mandible and unloaded for another 2 months to allow secondary stability. OMIs in the interradicular spaces where 1.6 mm diameter x 10 mm length (Jeil Medical corporation, Jet-screw JS, Korea, Seoul), and in the EOLG the OMIs sized 2.0 mm diameter x 14 mm length (Jeil Medical Corporation, Jet-screw- Korea, Seoul). A cephalometric x- ray (Orthophos SL 3D Sirona, Germany) was done just before the Herbst appliance placement (T1) and after its removal (T2) and dental, skeletal and mini-implants measurements were carried out with the software cephalometric analysis Nemoceph (Nemotech Biotech Dental Company, Madrid, Spain). Activations of the Herbst appliance in steps of 2-3 mm were done every 3 months gradually.

4. OMIs Placement Protocol

OMIs placement were performed under local anesthesia. A straight screwdriver did the insertion vertically in the IRG manually and a contra- angle piece was used in the EOLG. After placement, the mini-implants were untouched and unloaded during a healing period of 4-8 weeks in order to establish secondary stability. OMIs loading was made with a 0,12-metal ligature in the molar bands (EOLG) and in the lower canines brackets (IRG).

5. Statistical Analysis

Five patients were excluded in this study, 4 in the IRG and 1 in EOLG due to loss of implants. Descriptive analysis was conducted. Categorical variables were described with frequencies and percentages, while quantitative variables were described with mean, standard deviation, median, quartiles, minimum and maximum. To assess the statistical differences between the control groups, IRG and OELG a Kruskal-Wallis test was performed, and to evaluate pairwise differences between groups, Mann-Whitney U test were used. In all analysis p-values less than 0.05 were considered statistically significant. Analysis conducted with SPSS 25.0 (IBM Corp.).

6. Results

During the orthopedic treatment, 5 patients were excluded, 4 in the IRG and 1 in EOLG due to loss of implants. The patients treated with skeletal anchorage (IR and EOL groups) improved skeletally and obtained a dental correction into a class I. Skeletal anchorage has shown fewer lower incisors inclination in comparison to the control group (Table 1). The increase inclination of the lower incisor was present in all 3 groups after the treatment (CG=8,4º, IRG=2,9º, EOLG=1,7º). The inclination of the lower incisors was statistically significant between control group and skeletal anchorage groups (p=0.001). Although there were not statistically significant differences between both skeletal anchorage groups (IRG vs EOLG) (p=0,341). The skeletal values of ANB and WITS treated with skeletal anchorage were better in comparison to the control group (Table 2). Regarding ANB values, just CG versus EOLG group comparison was statistically significant (p=0,003). WITS values instead were significant in both skeletal groups compared to the control group (EOLG/p=0,001 and IRG/ p=0,001) (table 2). WITS and ANB improved in the CG 1,7º and 1,8ºrespectively, -3º and -2,4º respectively in the IRG and lastly, -3,3º and -2,9º respectively in the EOLG (table 1). The inclination of OMIs regarding the mandibular plane (Go-Gn) showed a better stability in the EOLG rather than in the IRG. MT1 and MT2 measurement showed OMIs mesial inclination of 2,57º and 2,43º respectively in the IR group. For EOL group, MT1 and MT2 measurements were an increased inclination of 0,2º in both measurements (table 1). Difference between both groups IRG and EOLG was indeed less than 2,5º (p=0,022 in MT1 and p=0,064 in MT2). The two groups with the skeletal anchorage, IRG and EOLG, did not show any significant differences in the inclination of the lower incisors, the ANB nor in the WITS values (p=0,341; p=0,172; p=0,709 respectively). In this study 5 OMIs lost stability during treatment and were taken out of the study. OMIs failed more frequently in the IRG than in the EOLG. The OMIS failure relation between the IRG and the EOLG was 4:1.

7. Discussion

Herbst has been demonstrated to be an effective tool to correct skeletal Class II malocclusions. It has a dental effect that reduces the overjet by means of proinclination of the lower incisors. The combination of skeletal effect and proinclination of the lower incisor, contributes in the correction of the Class II malocclusion, and establishes a Class I dental relationship. Other techniques have tried to control the inclination of the lower incisor such as torque control information in the stainless-steel arches or brackets slot information. Though, in most occasions this inclination was already increased before treatment because of mandible retrusion with compensatory proinclination. For this reason, further proinclination should be avoided during the correction of the sagittal discrepancy, indicating that skeletal anchorage is a useful tool. The Herbst appliance used in this study had the disadvantage of moving the teeth (more easily) buccally due to the vestibular braces position before the desirable orthopedic effect. Therefore, it adversely favors a greater proinclination of the lower incisor when compared to other Herbst that work without braces. It is for this reason, that the use of mini- implants is highly recommended, especially in orthopedic class II appliances designs that works in combination with braces. During the design of the study, in the most severe cases the patient's parents were duly informed to perform an orthognathic surgery treatment with mandibular advancement. Those patients who refused the surgical alternative were assigned to the randomized study. The selection of the patients to use Herbst appliance in combination with OMIs placement was recommended in those patients with inclination of the lower incisors to the mandible plane greater than 100º to avoid further incisor pro inclination during the orthopedic treatment in the sagittal discrepancy. A randomized method to assign the control group in patients with very provinciated lower incisors was considered inappropriate and unethical, and therefore the randomization within these patients was only assigned to the conventional device-anchoring mode, interradicular vs. external oblique line. This was done to avoid the unnecessary risk of potential gingival injuries. The Herbst appliance used and the bracket system prescription were the same for each patient in order to control the variables of the study. With the aid of interproximal enamel reduction techniques used during the alignment and leveling phase, no additional inclination of the lower incisor further than 2mm occurred. Exceeding this value meant the exclusion of the study.

Wit's analysis was used to assess the severity of the Class II. The values may vary considerably during the correction of the lower arch Curve of Spee and the position of the lower incisor. To reduce the bias of the methodology, the measurement in the cephalometric x-ray was carried out after 6-8 months of the bracket's placement with its 0,019x 0,025" stainless steel arch wires in place, once the leveling, alignment and crowding was duly corrected. At this stage, the placement of the Herbst appliance produced few arch wire deformations during orthopedic mandibular advancement. For similar reasons, the Steiner ANB measurement was performed at the same time as the Wits measurement, since it is known that point A can undergo modifications during correction of the upper incisor inclination, especially in retruded and retroclined upper incisors. Although small degrees differences (between 1-3º) in the measurements before and after the treatment were found, the landmark identification of A and B points in cephalometric Steiner analysis has been proven as a safe, standardized and reliable method of measurement and it demonstrates a more favorable response of the orthopedic treatment with OMIs in this study, specifically in the EOLG group (p=0,003). And even if IRG was not statistically significant, ANB improved -2,4º (IRG p = 0.24) (table 2).

The study demonstrated the efficiency of the skeletal anchorage to prevent the lower incisor from further proinclination (Table 2, p= 0.001). It is known that OMIs placed in bone might move when they are loaded under constant forces around 400g, especially those with small diameters and lengths. Cortical bone thickness is also a big factor in this stability loss. Which is why this study was divided in 2 groups of skeletal anchorage. Less interradicular cortical thickness (<1mm) compared to the external oblique line (2-3mm), suggests greater risk of mini-implants failure, as seen in the IRG (4:1). Although these 4 patients were excluded from the study, the anchorage loss in the IRG compared with the EOLG would produce surely statistically more significant skeletal changes, not seen in this study (Table 2, p= 0.172 for the ANB analysis, p=0.709 for the Wits analysis).

The skeletal effect of the Herbst appliance in combination with OMIs anchorage evaluated in this study coincides with other studies' results. The benefits in Wits skeletal response (p=0.001 in IRG, p=0.001 in EOLG), ranged from -3,02mm to -3,25mm (Table 1). A direct orthopedic load on the mini-implants with the Herbst appliance was not recommended because of the increasing risk of implant failure so an indirect anchoring with a small ligature was used. Lower incisor proinclination as a side effect could not be completely avoided in all samples. Small implants movement during loading or an insufficient wire tightness or tension in the molar bands during the strong orthopedic forces could have affected the wire ligature or created deformations. The anchorage efficiency between the EOLG and the IRG did show statistically significant differences in the MT1 measurements (p=0,022) and almost statistically significant differences in the MT2 measurements (p=0,64). Yet, the lower success rate of the OMIs in the IRG suggested that the small OMIs diameter in the interradicular spaces were not as effective for orthopedic forces of 400g, especially in areas with root proximity, where implant mobility could occur.

A cephalometric X-ray was taken just before and after the treatment. They were used to measure skeletal structures as Wits, Steiner ANB analysis, OMIs and dental measurements. Comparison of measurements in cephalometric X-rays is described in the scientific literature as a reliable, accurate and safe method, as long as the same X-ray machine is used. Although the landmark identification can lead to errors, measurements were carried out twice by two experienced operators. The OMIs inclination to the mandibular plane was very similar to the method of measuring the inclination of the lower incisor to the mandibular plane. This was possible because the OMIs insertion was carried out in a vertical and apical inclination, facilitating the visualization of its axiality and therefore allowing the standardized method of measurements. The inclination of the implants related to the mandible plane revealed that the mini-implants were not stable during the orthopedic loading in the IRG.

All treated patients in the 3 groups at the end of the orthopedic treatment reached a molar and canine class I occlusion, confirming the findings of the effectiveness of the Herbst appliance in normalizing the skeletal parameters.

When using implants as skeletal anchorage the reduction of the dentoalveolar compensations can improve the skeletal response (Table 1and 2). Therefore, the reduction of the lower incisor inclination during the activations of the Herbst appliance, allows further activations to adequate temporomandibular joint and neuromuscular adaptations in a more anterior mandible position to enhance favorable bone remodeling. The results of the study showed benefits of the OMIs in the skeletal response. Nevertheless, results should be interpreted with caution because there is no statistical difference between these two study groups (EOLG and IRG). And even though no clear differences amongst the IRG and the EOLG were found, with 5 patients excluded from the study, there is a clear tendency towards external oblique line location as a better OMIs location (table 1). Further studies in the OMIs success rate with greater sample size must be carried out in the future to corroborate the ideal OMIs position in combination with the Herbst appliance for the effectiveness of the orthopedic response [1-30].

8. Conclusion

The combination of orthodontic mini-implants with the Herbst appliance improved the skeletal response by reducing the excessive lower incisor inclination and improving WITS and ANB values. The mandibular buccal shelf location provided greater OMIs stability and less OMIs failure, that is why it should be selected to avoid implants mobility during the orthopedic treatment.

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