Anchorage loss due to Herbst mechanics—preventable through miniscrews?

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Summary

Aim: To assess if mandibular incisor proclination and protrusion during treatment with the Herbst/multibracket appliance can be prevented through simple screws (MIs) anchorage.

Material and methods: After a statistical power analysis, 12 Herbst patients with MIs (100% MIs survival) ligated to the Herbst/multibracket appliance to reinforce anchorage were investigated. A control group matched for gender and skeletal maturity treated without MIs anchorage was selected. Pre- and posttreatment cephalograms were analysed for overjet reduction, mandibular incisor proclination (IL/ML), protrusion (Ii-MLp) and intrusion (Ii-ML), as well as occlusal plane inclination (OP/ML) by a single-blinded examiner.

Results: No statistically significant differences between the two groups were found concerning overjet reduction, incisor protrusion- and intrusion or occlusal plane tilt. Although the MIs group generally showed less lower incisor proclination (4.8°) than the group without skeletal anchorage (6.5°), a large interindividual variation was observed.

Conclusion: Interradicular MIs anchorage cannot prevent anchorage loss during Herbst treatment. For the individual patient, the amount of incisor proclination and protrusion remains unpredictable.

Introduction

Due to the high demand for efficient orthodontic treatment, the Herbst appliance has become increasingly popular for the treatment of Class II malocclusions. It is the most commonly used appliance for Class II treatment in USA (1, 2). However, proclination and/or protrusion of the lower incisors can be an undesired side effect (3). When Emil Herbst first introduced the appliance in 1909 (4), the anchorage unit in the lower jaw consisted of two bands on the lower canines only. Since the reintroduction of Herbst treatment into modern orthodontics by Pancherz (5), many different designs testing a variety of different anchorage forms (i.e. extending the appliance to the lower first molars, applying acrylic splints or brackets on the lower incisors, reinforcing anchorage through Class III elastics, and a variety of mandibular cast splint designs) have been used, but to our knowledge none have been able to prevent or consistently reduce mandibular incisor proclination or protrusion (5–11).

New techniques developed in orthodontics, over the past 10 years however may offer better possibilities for preventing the above-mentioned unwanted side effects on the lower incisors: customized lingual orthodontic appliances with full size archwires have shown to prevent lower incisor proclination and/or protrusion during Herbst treatment, supposedly because of better torque control (12). For conventional labial bracket systems however, there appears to be too little torque control to withstand the mesially directed forces on the mandibular teeth, produced by the telescope mechanism. Using skeletal anchorage, however could be a method to provide the necessary stability preventing inadvertent lower incisor movement. Case reports have shown the efficacy of combining Herbst appliance derivatives with inter-radicular miniscrews (MIs) combined with various types of stainless steel lace backs (13, 14).

Aim

The aim of this study was to assess whether mandibular anchorage loss during treatment with Herbst/multibracket (MB) appliances can be prevented, using inter-radicular MI anchorage. The
null hypothesis was that Herbst/MB treatment with or without MIs anchorage results in equal amounts of anchorage loss (mandibular incisor proclination).

**Subjects and methods**

Since the clinical difference between implant supported and unsupported groups was unknown prior to starting the study, a power calculation was performed in order to recruit the smallest sample size that would allow meaningful statistical analysis. We theorized that group I (with MIs) would demonstrate about 4–5 degrees (13) and group II (without MIs) about 7–8 degrees of proclination; this assumption was based on previous data from case reports (15). About 10–13 patients were required in both groups to achieve a power of 0.80 with $\alpha = 0.05$. This protocol was approved by the ethical committee of the University of Homburg/Saar, Germany (No. 23/13).

Starting in 2010, MIs of 8 mm (Ortho Easy®, 1.8 mm diameter, Forestadent, Germany) were routinely placed bilaterally between the lower second premolar and the first molar of Herbst patients to reinforce anchorage (office B. L.). The MIs were placed at an oblique angle at the level of the mucogingival line. This procedure was performed in 17 consecutive patients, of whom 5 had screw failures during the course of Herbst treatment. Twelve patients (9 males, 3 females) remained (all Caucasian teenagers), and their datasets were evaluated for this study. From the same office a control group with matched pre-treatment overjet and skeletal maturity (cervical vertebral maturation method) (16), was retrospectively selected (5 males, 7 females). This control group was treated using an identical protocol, except for MI anchorage. Both groups contained patients with only minor crowding or well aligned arches with a bilateral Class II molar occlusion of at least 1/2 cusp. No patient with a great excess or lack of space was included and there were no extraction cases in the present material, neither in the MIs nor in the control group. A self-ligating MBT prescription appliance with an active clip, −6 degrees lower incisor torque and an 0.022″ × 0.025″ slot was used. The final archwire used for anchorage was 0.019″ × 0.025″ stainless steel. The bite jumping mechanism used in both groups was the Easy-Fit Jumper® (Forestadent, Pforzheim Germany).

In the lower dental arch, the archwire was cinched-back and anchorage was reinforced with an elastic chain (2N) between the lower first molar and the Herbst appliance (Figure 1a). In the MI group, an additional active laceback (4N) between mandibular Herbst axle and MI inserted (b) active laceback (4N) between mandibular Herbst axle and MI inserted.

Lateral headfilms were taken before (T0) and at the end of active treatment (T1) with a Sirona Orthophos XG5 X-ray unit (enlarge ment factor 10 per cent). Radiographs at T1 were taken before the MB appliance and pins had been removed. The images were traced and evaluated by hand. Overjet, mandibular incisor proclination (IL/ML), incisal edge advancement (Ii-MLp), and incisal edge intrusion (Ii-ML) were measured (Figure 2). The evaluation was performed by one single blinded examiner (J. v. B.).

Intra-examiner reliability was assessed by repeating all linear and angular measurements after 3 months. The mean coefficient of variation (COV), was 0.08 (range 0.05–0.14). No statistical significance ($P > 0.05$) was found between COVs.

Statistical analyses were performed with SPSS (Version 19.0, SPSS Inc., USA). To test for equality of variances, Levene’s test was applied. Shapiro–Wilk tests were carried out to test for normality. In case of normal distribution, Student’s $t$-tests were used for intergroup evaluation; otherwise, Mann–Whitney $U$-tests were carried out. Comparisons of intragroup differences (pre-/post-treatment) were undertaken using paired $t$-tests for normally distributed values and Wilcoxon tests for not normally distributed values. The categorical data were analysed with Chi-square and Fisher’s exact tests. Statistical significance was set at $P \leq 0.05$. 

![Figure 1. Treatment and control groups using Herbst appliance. (a) Control group: Herbst appliance on 0.019″ × 0.025″ stainless steel archwires with cinch back and anchorage reinforcement through (a) power chain (2N) from molar hook to Herbst axle. (b) Miniscrew (MI) group: Herbst appliance on 0.019″ × 0.025″ stainless steel archwires with cinch back and anchorage reinforcement through (a) power chain (2N) from molar hook to Herbst axle plus (b) active laceback (4N) between mandibular Herbst axle and MI inserted between lower second premolar and first molar.](image)

![Figure 2. Measurement of (a) mandibular incisor proclination (IL/ML, degree), (b) mandibular incisal edge advancement parallel to ML (Ii-MLp, mm), (c) incisor intrusion perpendicular to ML (Ii-ML, mm), and (d) occlusal plane tilt (OP/ML, degree).](image)
Results

The mean age at start of treatment was 12.0 ± 1.6 in the MIs group and 12.9 ± 2.2 years in the control group, with no significant differences between the two groups (P = 0.233). The pre-treatment overjet of all patients was 7.5 ± 1.5 mm, with no significant difference between the two groups. All patients were past their pubertal peak of growth (CS 4–6). The average duration of stage I (MB treatment) was 11.6 ± 1.2 months for the MIs group and 11.2 ± 1.1 months for the control group. The average treatment time of the Herbst stage was 4.6 ± 0.4 months for the MIs group and 4.7 ± 0.8 months for the control, with no significant differences between the two groups.

Overjet

At the time of appliance removal, all patients had been successfully treated to a Class I molar relationship with a normal overjet (2.1 ± 0.7 mm).

Table 1. Mean cephalometric treatment changes (T1–T0) between Herbst patients with (IMs) and without (control) miniscrew reinforced anchorage.

<table>
<thead>
<tr>
<th></th>
<th>OJ T1–T0 (mm)</th>
<th>IL/ML T1–T0 (°)</th>
<th>II-MLp T1–T0 (mm)</th>
<th>II-ML T1–T0 (mm)</th>
<th>OP/ML (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMs group</td>
<td>5.6 ± 1.7</td>
<td>4.8 ± 4.9</td>
<td>1.1 ± 1.5</td>
<td>0.3 ± 2.25</td>
<td>4.5 ± 2.5</td>
</tr>
<tr>
<td>Control group</td>
<td>5.3 ± 1.4</td>
<td>6.5 ± 9.4</td>
<td>1.7 ± 2.9</td>
<td>0.5 ± 3.3</td>
<td>5.1 ± 4.0</td>
</tr>
<tr>
<td>p values</td>
<td>0.883</td>
<td>0.023</td>
<td>0.083</td>
<td>0.074</td>
<td>0.093</td>
</tr>
</tbody>
</table>

Mandibular incisor proclination

Before treatment, the MIs group had an average IL/ML angle of 93.5 degrees, which, after removal of the Herbst appliance, had increased by 4.8 ± 4.9 degrees to 98.3 degrees. The control group had an average pre-treatment IL/ML angle of 99.5 degrees, which had increased by 6.5 ± 9.4 degrees to 106.0 degrees after removal of the Herbst appliance (Table 1; Figure 4). Comparing the groups, MIs demonstrated significantly less incisor proclination during treatment compared to the control group (Student’s t-test; P = 0.023). Inter-individual variation was substantial in both groups, but it was particularly large for the control group. The difference in incisor

Figure 3. Overjet (OJ) reduction of miniscrew (MI) anchored Herbst/ multibracket (MB) group (n = 12) and non-MI-anchored Herbst/MB control group (n = 12).

Figure 4. Mandibular incisor proclination (IL/ML) changes during treatment (T1–T0) of miniscrew (MI)-anchored Herbst/ multibracket (MB) group (n = 12) and non-MI-anchored Herbst/MB control group (n = 12).

Figure 5. Mandibular incisal edge advancement (II-MLp) changes during treatment (T1–T0) of miniscrew (MI)-anchored Herbst/ multibracket (MB) group (n = 12) and non-MI-anchored Herbst/MB control group (n = 12).

Figure 6. Mandibular incisor intrusion (II-ML) changes during treatment (T1–T0) of miniscrew (MI)-anchored Herbst/ multibracket (MB) group (n = 12) and non-MI-anchored Herbst/MB control group (n = 12).
proclination was the only comparison that reached levels of statistical significance.

**Mandibular incisal edge advancement**

On average, the lower incisors of the MI patients advanced 1.1 ± 1.5 mm during Herbst therapy, while those of the control group advanced slightly more (1.7 ± 2.9 mm) with a larger inter-individual variation (Table 1; Figure 5). The difference between the groups was not statistically significant (Student’s t-test; *P* = 0.083).

**Mandibular incisor intrusion**

The amount of incisor intrusion (Ii-ML) was slightly smaller (0.3 ± 0.9 mm) in the MI group compared to the control group (0.5 ± 3.3 mm). This difference was not statistically significant (Student’s t-test; *P* = 0.074) (Table 1; Figure 6).

**Occlusal plane inclination**

On average, the occlusal plane angle (OP/ML) decreased less in the MI group (4.5 ± 2.5 degrees) than in the control group (5.1 ± 4.0 degrees), again with a large inter-individual variation, which was more pronounced in the control group. The differences did not reach level of significance (Student’s t-test; *P* = 0.093) (Table 1; Figure 7).

**Discussion**

This study investigated only patients where MI treatment had been successful. Patients with failed MIs were excluded. Although inclusion of the latter group would have resulted in a larger sample size, this would have resulted in unreliable results regarding the ‘cause and effect’ relationship between implant placement and the resulting incisor proclination. This study aimed to analyse the best effect possible, which can only be ascertained if the MIs are present throughout the entire Herbst treatment.

To minimize bias, all patients were selected from one orthodontic office with one operator (B. L.) inserting all MIs. Even though this practitioner is very experienced in inserting MIs, an implant failure rate of 30 per cent was observed, which exceeded the operator’s average loss rate.

Many authors have tried to assess factors affecting the clinical success of MIs (17–21), and the anatomical region of insertion appears to be one of them. High success rates have been described for indirect MIs anchorage in the premolar/molar region of the mandible (22) and it has been shown that this site offers the most suitable bone for pin placement in the mandible (22, 23). However, these success rates could not be confirmed in the present investigation.

Another important factor influencing the clinical success of MIs is their proximity to the adjacent roots (24, 25); but this should not be a major factor in the lower premolar/molar region. However, due to effects of the Herbst appliance, molars often mesialise during treatment and can thereby come into contact the IM. This might explain the high frequency of screw loosening, which unfortunately reduced the present material to a smaller sample size. Nevertheless, the residual sample was homogeneous in terms of presenting malocclusion, with a well-matched control group. Matching was, amongst other things performed to pre-treatment skeletal maturity; since the lower incisors of patients treated after the pubertal growth peak tend to procline more than those of patients presenting at pre-peak height velocity of the growth spur (26). The pre-treatment overjet of the two groups was matched since a correlation between the amount of bite jumping and mandibular incisor side effects can be expected (15). Thus, the small sample size, which was treated with an identical treatment protocol, except for the MIs, proved to be sufficient to extract representative data for the calculated power of 80 per cent.

Of all variables analysed, the amount of lower incisor proclination (II/ML) was the only variable showing a statistically significant difference between the two groups. However the average difference between the two groups was not even 2 degrees, which is not relevant clinically. The amount of proclination found in our investigation was much smaller than that of other studies, where cast splint appliances were used and II/ML changes between 9.3 and 12.9 degrees (10, 11) occurred.

A previous investigation showed that good tip and torque control of the lower incisors, using completely customized lingual appliances and full size archwires, was able to prevent lower incisor proclination, (IncognitoTM, 3M Unitec), preventing not only anchorage loss, but resulting in anchorage gain i.e. retroclination of the lower incisors (12). The above study however used scanned plaster casts to assess incisor proclination and not lateral cephalometric headfilms. However, to our knowledge no comparisons of inclination change measurements between plaster casts and cephalometry have been undertaken and it remains unclear to what extent crown torque changes assessed by one method correspond to the root inclination changes by another.

Another recent paper (13) also demonstrated good control of incisor side effects using labial fixed appliances in combination with a MI-anchored Herbst appliance; however this was based on a single case report. The substantial interindividual variation found in our study may help to explain the favourable outcome of this case report. Interestingly in our investigation, retroclination of the incisors was observed in some patients of both the MI as well as the control group, whereas other subjects of both groups suffered significant anchorage loss. Similarly, patients treated with cast splint Herbst appliances without any anchorage reinforcement sometimes do not show significant changes of lower incisor position (27). One possible explanation for the great variation of the incisor inclination change previously reported can be the amount of pre-treatment crowding; patients with crowding at start of treatment are likely to show more incisor proclination during the aligning and levelling phase, compared to patients with a spaced dentition. However, for the present material, only cases with well aligned arches or minor crowding or spacing were included. We can therefore safely assume that the observed effects were to a large程度
extent caused by the Herbst appliance and not because of the side effects of aligning the teeth.

Another factor often discussed is the torque play of an 0.019 × 0.025 archwire in a 0.022 × 0.029 slot. An 0.021 × 0.025 archwire would have had fuller torque expression, but this dimension archwire could not be used here because of the anchorage unit design of the Herbst appliance (crimpable tubes). Furthermore, since an identical treatment protocol was used for both groups the effect should have been the same for both groups.

Apart from the IL/ML angle, no statistically significant differences were found between the two groups. What was striking, however, was the large interindividual variation in both groups for all measurements. This large variation of has been described in a number of previous studies, evaluating the effects of Herbst treatment (6, 8, 10, 11, 27, 28), but the reasons for it remain unknown. Although the average amount of anchorage loss and the amount of interindividual variation were smaller in the MI group, in view of the small net gain of 1.7 degrees less proclination, 0.6 mm less intrusion, 0.2 mm less intrusion and 0.6 degrees less occlusal plane tilt in the MI group, the clinical significance and predictive impact of a MI anchorage for Herbst patients must be questioned.

Conclusion

MI anchorage as used in this study did reduce proclination of the lower labial segment to a small extent, but could not prevent it reliably. The differences in anchorage preservation between the study and control groups, although statistically significant, were small and were unlikely to be of clinical relevance.

The relatively small anchorage benefits of MI anchorage, the large interindividual variation as well as the high loss rate do not appear to justify their additional expense.

Extrapolating from the data of this study, we cannot recommend routine use of MI in conjunction with Herbst appliance treatment to prevent proclination and/or protrusion of the lower incisors.

References