



## **MASTER ASSIGNMENT**

# **Treatment outcome in patients with anterior crossbites in the student clinic in Tromsø**

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# **Abstract**

## **Objectives**

The aim of this study was to assess orthodontic treatment outcome and quality of documentation in patients with different types of anterior crossbite, who had received and finished treatment at the student clinic in the period between 2008 and 2010.

## **Subjects and Methods**

The subjects were all patients who had received orthodontic treatment because of anterior crossbite in the student clinic in Tromsø during the period 2008 to 2010. A total of 34 subjects (mean age 9.3 years) fulfilled the inclusion criteria and were enrolled in the study. Existing pre and post treatment records from all subjects, consisting of notes in patient journals, plaster models, clinical photographs and lateral cephalograms, was collected and supplemented by recalling of subjects. Data on occlusion pre and post treatment and the course of treatment was based on patient journals, plaster models, clinical photographs and lateral cephalograms. The definition of the treatment being successful was that positive overjet was achieved in all four incisors.

## **Results**

The mean age at start of treatment was 9,3 years ranging from 8-12 years. Approximately half of the patients (53 %) had only single incisors in crossbite, the rest had 2-4 adjacent incisors in crossbite. The treatment was successful in 68 % of the patients included in the study, and the treatment tended to be more successful in patients with only single incisors in crossbite. Important determining parameters for the treatment outcome were the duration of active treatment and patient compliance. The treatment success rate was significantly higher in subjects who were treated 8 months or less as compared to subjects who had longer treatments. Post treatment plaster models and clinical photos were missing or inadequate in more than half of the patients.

## **Conclusions**

Our results suggest that 2 out of 3 anterior crossbites were successfully corrected in the university student clinic in Tromsø, and longer treatment time seemed to affect the treatment success negatively. The common lack of post-treatment documentation calls for considerable improvement.

## **Introduction**

### **Anterior crossbite**

An occlusal disorder where one or more of the upper incisors are in reverse overjet relative to the lower arch, which means that the upper incisors are lingual to the lower incisors, is called anterior crossbite. If all four upper incisors (or at least both upper central incisors) are lingual to the lower incisors it is called negative overjet.

Inversion of incisors usually refers to a situation where one to three individual incisors are in anterior crossbite. The etiology is dentoalveolar, e.g. crowding in the upper arch or a retained primary incisor, which leads to one or more palatally displaced incisors from the arch. The prevalence of one or more inverted teeth was reported to be 11 % in a study on Swedish schoolchildren<sup>1</sup>.

Anterior crossbite may be due to abnormal inclination of the maxillary and mandibular incisors, occlusal interferences, or skeletal discrepancies of the maxilla and/or mandible<sup>2</sup>. Individuals with Class III malocclusion may have combinations of skeletal and dento-alveolar components<sup>2</sup>. In clinical orthodontics, it is important to make the differential diagnosis between skeletal and dento-alveolar anterior crossbite due to differences in treatment modalities in these patients regarding timing, duration and difficulty of treatment, which affect the success of treatment (Table 1). Sometimes, e.g. in mild Class III cases, the differential diagnosis is not always clear, because both dento-alveolar and skeletal Class III characteristics may be present.

### **Dento-alveolar anterior crossbites**

The majority of dento-alveolar anterior crossbites are caused by local environmental factors. These factors, such as retained primary teeth, odontomas, trauma, crowding, etc., could change the normal path of eruption allowing the upper incisors to erupt palatally and/or the lower incisors to erupt labially<sup>3</sup>. In children and adolescents in Bogota Colombia the prevalence of Pseudo Class III was reported 2,1 %<sup>4</sup>. In a study on Swedish schoolchildren the prevalence of

prenormal occlusion was found to be 4,2 %, where 35,7 % were forced anterior guidance<sup>1</sup>.

Dento-alveolar anterior crossbites are typically accompanied by anterior shift from CR to IP, also known as anterior forced bite. When guided into CR, the patients can obtain an edge-to-edge incisor relationship and the occlusal interference in the incisor(s) guides the mandible into anterior crossbite in IP. If diagnosed early, the patients have a normal ANB angle in CR. These malocclusions present with molar Class I in CR, and Class I or Class III in IP<sup>5</sup>. The inclination of the upper incisors is typically upright, and the inclination of the lower incisors is normal or labial (Table 1).

### **Treatment**

The correction of the anterior crossbite in dento-alveolar anterior crossbites is recommended to be carried out in the early mixed dentition<sup>5</sup> to prevent it from getting worse and resulting in a full-blown Class III malocclusion<sup>6</sup>. The treatment can be managed with a removable plate consisting of an active element, protrusion screw or push spring, which push the upper incisors forward, and buccal capping to free the occlusion from the opposing arch. The duration of treatment is usually short, 4-6 months, with retention time up to 1 year, and a general practitioner can carry out the treatment. In dento-alveolar anterior crossbites a normal or increased overbite is an advantage, as a vertical overlap of the upper incisors with the lower incisors post-treatment is vital for stability. The treatment of one or more inverted incisors is the same as for dento-alveolar anterior crossbites.

### **Skeletal Class III malocclusion**

The etiology of Class III malocclusions can be genetic or environmental<sup>2</sup>. Studies on the Hapsburg family and their prognathic mandible, segregation analysis of mandibular prognathism in Libya<sup>7</sup>, and analysis of large European noble families<sup>8</sup>, all support the idea that growth and the size of the mandible are affected by heredity<sup>2</sup>. The prevalence of Class III malocclusions varies among

different ethnic groups, and the prevalence in the Caucasian population is approximately 3-5 %<sup>2</sup>.

Typical occlusal characteristics of skeletal Class III are Angle Class III relation in molars and canines, and anterior crossbite (Table 1). Dento-alveolar compensation in the inclination of the incisors can be seen with proclination of the upper incisors and retroclination of the lower incisors (Table 1). This results in the incisor relationship being less severe than the underlying skeletal pattern. Anterior shift from CR to IP, which is commonly found in dento-alveolar anterior crossbites, can also be present in skeletal Class III malocclusions in the early mixed dentition. If such a displacement is present, the prognosis for correction of the anterior crossbite is more favourable<sup>9</sup>.

The skeletal characteristics of true Class III malocclusions are mandibular prognathism, maxillary retrognathia, or a combination of both<sup>3</sup>. The patients have a skeletal discrepancy, which is seen from their concave profile. In the cephalometric analysis these patients have either a decreased SNA angle or an increased SNB angle or both, so that the ANB angle is negative. A posterior rotation growth pattern of the mandible will camouflage the skeletal Class III pattern and reduce overbite with growth<sup>9</sup>. If there is an anterior rotation growth pattern of the mandible, there will be increased prominence of the chin and worsening of the skeletal pattern and the negative overjet with growth<sup>9</sup>.

The skeletal and dental components of Class III malocclusions are present already in early childhood, and tend to worsen with growth if left untreated, e.g. increased dento-alveolar compensation by proclination of upper incisors and retroclination of lower incisors, worsening of mandibular prognathism and sagittal skeletal discrepancy between the jaws with growth<sup>10</sup>. In a study among untreated Class III patients, changes in angle ANB, Wits appraisal and molar relationship indicated a worsening of the Class III relationship with increasing skeletal maturity as the mandible outgrew the maxilla<sup>10</sup>. This, and the fact that the growth spurt in midfacial length occurs in the prepubertal period<sup>10</sup>, indicate early treatment of Class III malocclusions.

## **Treatment**

The evidence shows that the results of attempts to restrict mandibular growth are poor<sup>11</sup>. Therefore, the focus of early treatment of skeletal Class III malocclusion is in protraction of the maxilla. A commonly used appliance in the early management of skeletal Class III is the reverse-pull headgear or facemask, which apply an anterior directed force, via elastics, on the maxillary teeth and maxilla, and a passive chin cap holds the mandible back<sup>9,12</sup>. Rapid maxillary expansion is often used before maxillary protraction to mobilize the maxillary sutures and to enhance the protraction effect of reverse headgear. Using this method, correction of the anterior crossbite and Class III molar relationship can be achieved after 6 to 9 months<sup>11</sup>.

Treatment with facemask is most effective in Class III patients who have a retrusive maxilla, and the treatment has been found to be stable 2 years after removal of the appliance<sup>12</sup>. As with dento-alveolar anterior crossbites, sufficient overbite is important for post-treatment stability. Skeletal anterior crossbites should be treated in the primary or early mixed dentition for growth modification, and camouflage treatment with fixed appliances or surgery after growth<sup>13</sup>. Due to difficulty of treatment and frequent relapse, an orthodontist should carry out the treatment. The risk of relapse is highest during the pubertal growth spurt. Orthognathic surgery is considered when the Class III skeletal pattern is severe and when the patient is in permanent dentition and growth has finished. Mild Class III malocclusions in early mixed dentition and with sufficient overbite, may be treated as pseudo Class III anterior crossbites.

### **Treatment of anterior crossbite at the student clinic in Tromsø**

The patient population in the student clinic in Tromsø consists predominantly of growing children. Regarding anterior crossbite, in principle, the aim is to diagnose and treat all anterior crossbites as soon as possible, preferably in the early mixed dentition, to prevent them from becoming worse. The treatment modalities most often used are removable appliances, the retractor appliance with or without protrusion screws, buccal capping and a labial bow, and a removable plate with protrusion screws and buccal capping. Some of the Class III

patients who are treated early at the student clinic need specialist treatment later. Early treatment aims only for anterior crossbite correction, which is expected to reduce later need and difficulty of treatment<sup>14</sup>.

The integrated master program in odontology started in Tromsø in 2004. As the routines have not yet been fully established, some problems related to organization of treatment at the student clinic have existed. First of all, the students' restricted time at the clinic can prolong the duration of treatment for some patients, especially during the summer where students are not present at the student clinic. Another problem is that a patient may change operator one or several times during the treatment, and that different supervisors are involved in the treatment. The lack of continuity can affect the treatment negatively, thereby lowering the quality of treatment.

In orthodontics, evaluation of treatment success is usually done on each individual patient at the end of treatment. However, regarding the quality and success of treatment outcome, general evaluations of larger patient groups are needed to maintain quality control in the patient care and to improve the treatment practices. More comprehensive evaluations are based on patient documentations and can be carried out retrospectively. So far, evaluations of the orthodontic treatments carried out in the student clinic, are missing.

## **Objectives of the study**

The aim of this study was to assess orthodontic treatment outcome and quality of documentation in patients with different types of anterior crossbite, who had received and finished treatment at the student clinic in the period between 2008 and 2010.

## **Subjects and methods**

This study was a retrospective study based on patient records taken before and after orthodontic treatment.



## **Subjects**

The subjects were all patients who had received orthodontic treatment because of anterior crossbite in the student clinic in Tromsø during the period 2008 to 2010. All patient records were manually searched through to find patients with anterior crossbite diagnoses. Following inclusion criteria were used:

The subject had to have one to four incisors in anterior crossbite, the subject had received and finished treatment at the student clinic during the period 2008 to 2010 and acceptable pre treatment records encompassing journal notes, plaster models and/or clinical photographs had to be available.

In case of missing post treatment records the subjects were recalled to the student clinic for completing the records. The full post treatment records encompassed necessary notes in the patient journals, plaster models with index, clinical photographs and lateral cephalogram if pre treatment cephalogram existed.

The total number of subjects fulfilling with the pre treatment criteria was 34. 16 of them were recalled to the student clinic for completing the post treatment records. In 1 subject the anterior crossbite was confirmed through clinical pictures due to missing pre treatment plaster models.

## **Methods**

Data on occlusion pre and post treatment and on the course of treatment was received from patient journals, plaster models, clinical photographs and lateral cephalograms.

Patient journals were used to gather information on age at start of treatment, type of appliance used, duration of active treatment (months), number of appointments during treatment, retention time (months), patient compliance evaluated from the records and assigned as excellent, acceptable or poor depending on appointment attendance, use and breakage of appliance.

### *Plaster models*

Data collected from plaster models included the number of centrals and/or laterals in anterior crossbite, Angle classification in permanent molars, dental stage assigned as primary, early mixed, late mixed or permanent dentition, overjet and overbite (mm) on fully erupted teeth, measured on the most prominent central incisor, and anterior crowding assigned yes or no. Anterior crossbite was divided into three subgroups based on number of teeth in anterior crossbite (Figure 1).

1. One central, one lateral incisor or both lateral incisors in anterior crossbite.
2. One central and one lateral, two central incisors, two central and one lateral, and one central and two lateral incisors in anterior crossbite.
3. All four incisors in anterior crossbite.

### *Clinical pictures*

Profile pictures were used to evaluate the profile assigned as concave, straight or convex. Intra oral frontal pictures were used for confirming the diagnosis and treatment outcome in cases with missing or broken plaster models, which was the case in 1 subject.

### *Lateral cephalograms*

The parameters that were included and measured on the lateral cephalograms were the SNA, SNB and ANB angles, inclination upper incisor/NSL, inclination lower incisor/ML, SN/ML and the inter-incisal angle (Figure 2).

### *Evaluation of treatment success*

The treatment was considered being successful if positive overjet was achieved in all four incisors. The treatment was considered not successful if one or more of the following was recorded; the subject did not want to continue the treatment, positive overjet and overbite was not achieved during treatment, or the patient was referred to a specialist for further treatment.

### *Analysis of data*

The data was recorded and analyzed in SPSS for Windows 19. Means and frequencies for different variables were calculated. Pearson's chi square was used to test the differences between groups. Differences with P-values < 0.05 were considered as statistically significant.

### *Method error*

The examiners were calibrated by an experienced orthodontist to perform the occlusal measurements. The intra-class correlation coefficient (ICC) for overjet and overbite measurements between the two examiner groups ranged between 0.625-0.746 (=moderate to strong agreement) and between the examiner groups and the calibrating orthodontist 0.744-0.887 (=strong to almost perfect agreement). For Angle classification (right and left side) there was a 100 % agreement between the two examiner groups, and between the calibrating orthodontist and the examiner groups the agreement was 74 %. For evaluating the intra-examiner reliability, duplicate measurements were carried out on 16 randomly selected cases. The intra-examiner consistency between duplicate measurements of Angle classification ranged from 94 % to 100 % ( $\kappa = 0.763-1.00$ ), indicating substantial to almost perfect agreement. The ICC for the examiners duplicate measurements of overjet and overbite ranged between 0.691-0.927.

Cephalometric measurements were done by the authors (MUN, IV, ISM and AZ) using hand tracing method and by the computerized method by the supervisor (AM) (Facad version 3.5.0.3.). Because of marked differences between the values received by the two methods, the values from the Facad analysis method were used in the analyses.

## **Results**

The mean age of the patients at start of treatment was 9,3 years ranging from 8-12 years. Seventy-four percent of the subjects were in early mixed dentition, 21 % in late mixed dentition, and 2 subjects (6 %) in permanent dentition at treatment start (Table 2). Ten subjects (29 %) had a negative overjet pre-

treatment. For the rest of the subjects (24) the mean overjet was 1,9 mm (range 0-4 mm). Mean overbite before treatment was 2,1 mm (range 0-4 mm). Class I molar relationship pre treatment was found in 18 subjects (69 %), and the molar relationship did not change with treatment. Six subjects had Class II molar relationship and one of them changed to Class I with treatment. Two subjects had Class III molar relationship pre treatment, and the molar relationship changed to Class I in both of them with treatment. Eight subjects were missing records on angle classification pre and/or post treatment. The treatment was successful in 68 % of the subjects included in the study. The treatment success was 57% (12 out of 21) in subjects who had started the treatment before 10 years of age, and 85 % in the subjects with the treatment started at 10 years of age or later, although the difference did not reach statistical significance (Table 3). No difference was seen in treatment success between different dental stages (Table 2).

#### *Treatment success*

Orthodontic treatment was successful in 78 % of the subjects with only individual teeth in anterior crossbite as compared to 57 % success rate in subjects with 2-3 adjacent teeth in crossbite. When all four incisors were in anterior crossbite 1 out of 2 subjects (50 %) were successful. The differences were however not statistically significant (Table 4).

Twenty subjects (59 %) had maxillary anterior crowding pre treatment. Crowding was slightly more common (67 %) in subjects with crossbites of single teeth than in subjects with several or all anterior teeth in crossbite (50 %) (Table 5).

#### *Cephalometric analysis*

The cephalometric results were based on the 9 subjects who had cephalograms taken before and after treatment (Table 6). Seven of the 9 subjects had several anterior teeth in crossbite.

Three of the subjects with lateral cephalogram had a prognathic mandible pre treatment (SNB > 82 degrees) and 4 had a retrognathic maxilla pre treatment (SNA < 80 degrees).

The inclination of the upper incisors/SN increased with treatment in 8 of the 9 subjects with the mean pre-treatment value of 108 degrees and post-treatment 114 degrees. The mean inclination of lower incisors/ML decreased in the same subjects from 100 to 95 degrees during treatment (Table 6). The mean ANB and interincisal angles were low both pre and post treatment as compared to the norm values (Table 6).

#### *Factors related to orthodontic treatment and success rate*

The average duration of active treatment was 8,3 months ranging from 2-26 months. The average number of appointments was 6,4 ranging from 2-18. The treatment success rate was significantly higher (88%) in subjects who were treated 8 months or less as compared to subjects who had longer treatments (12%) (Table 7).

Duration of active treatment varied with the type of appliances used. Treatment time was longest with the retractor appliance, with an average of 9,7 months, and shortest for the acrylic plate, with an average of 7,1 months. The duration of active treatment was intermediate for the expansion plate, with an average of 8,4 months.

Subjects with all four incisors or both central incisors in anterior crossbite were treated with a retractor appliance in 7 out of 8 cases, and with an expansion plate with protrusion screw(s) in one case. The rest 26 were treated with either an acrylic plate with protrusion screw(s) or an expansion plate with protrusion screw(s). The success rate was highest with the acrylic plate with protrusion screw(s) (88 %) and lowest with the retractor (57%), but the differences were not statistically significant (Table 8).

Patient compliance was excellent in 42 % of the patients, 52 % showed acceptable cooperation and 6 % had poor cooperation during the treatment. There was found no difference in the compliance between the younger and older patient groups or between the dental stages. Treatment was successful in 87% of the patients with excellent cooperation as compared to 55 % in patients with acceptable/poor cooperation ( $p=0.063$ ).

The patient compliance was almost significantly different between the appliances used to correct anterior crossbite ( $p=0.056$ ). Excellent compliance

was most often met with the expansion plate with protrusion screw(s) and acrylic plate with protrusion screw(s), whereas with all subjects using a retractor the cooperation was somewhat compromised (Table 9).

#### *Documentation of treatments*

Out of the 34 subjects 23 had panorama radiographs pre-treatment and 9 subjects post treatment. Only 3 subjects had panorama radiographs both pre- and post-treatment. Nine subjects had lateral cephalogram pre-treatment and none of these had lateral cephalogram post-treatment.

Five out of the 34 subjects did not have any pre treatment clinical pictures or had pictures of poor quality which could not be used for diagnostic purposes. Clinical photographs post treatment were lacking or considered not sufficient in 20/34 subjects. Of these, 16 subjects were recalled to the clinic to complete the post treatment records. The remaining 4 subjects were already referred to a specialist, confirmed by notes in the patient journals.

There were more subjects lacking the extra-oral than the intra-oral clinical pictures, 12 and 5, respectively. In all 12 cases information about the profile was missing.

Seventy-nine percent (27/34) of the subjects had adequate plaster models pre-treatment. For 1 subject pre treatment plaster models were missing, in 6 subjects the models were of poor quality. Poor quality were in these cases related to fractured anterior teeth, which compromised measurement of overjet and overbite. In all of these cases the clinical pictures were used to confirm the clinical condition pre treatment. Plaster models post treatment lacked in 20 subjects. Of these, 16 subjects were recalled to have their dental casts taken to complete the post-treatment documentation. The remaining 4 subjects had already been referred to a specialist.

## **Discussion**

This study included 34 subjects. There were more subjects treated for anterior crossbite at the student clinic from 2008 to 2010, but the inclusion criteria were strict and many of these were excluded from the study, mainly because the patient had not been treated in the given time period. With the small sample size

the power of the study was too low to reach statistical significance for the differences found. Thus, our sample is not representative for generalizing the results to any other population, but it gives information on local level on the treatment success at the student clinic in Tromsø.

In orthodontic cephalometrics it is important to keep method error to a minimum in order to see the valid small changes achieved by treatment<sup>15</sup>. Hand tracing is time consuming and errors may arise from acquisition of radiographs, tracing, landmark identification, and measurements<sup>15</sup>. In this study it was decided to use the results of the digital measurements instead of the results of hand tracings, although Sayinsu et al reported that the validity and reproducibility of the measurements with the Dolphin Imaging Software and with the conventional method were highly correlated. This was decided because of the source of error in finding the landmarks due to poor image quality in the prints. Also Sayinsu et al concluded that the digitalized method could be preferred for research purposes. One source of error in this study was also the inconsistent occlusion position during cephalometric radiographing. Most of the lateral cephalograms were taken in IP pre- and post treatment.

### **Occlusal characteristics and treatment outcome**

The results showed that the average start of treatment was 9,3 years, and no correlation was found between age at start of treatment and treatment success. Treatment of anterior crossbite should be carried out in the early mixed dentition, particularly if central incisors are involved<sup>16</sup>. In this study 74 % of the subjects started treatment in the early mixed dentition with the success rate of 68 %. Somewhat lower success of treatment was found when the subjects started treatment in the late mixed dentition (57 %). Only 2 subjects started treatment in the permanent dentition, and their treatment was successful. These subjects only had one or two laterals in anterior crossbite with no skeletal Class III involvement, which is expected to be easier to treat than a full anterior crossbite. The small number of subjects treated in the permanent dentition makes a poor foundation for comparison, and a less successful result might have been expected if the sample size was bigger.

In our study, the treatment of patients at the student clinic aimed only for anterior crossbite correction, which is expected to reduce eventual later need and difficulty of treatment. For the most part, the treatment resulted in anterior crossbite correction, and all successful cases had a positive overjet in all four incisors post treatment. The success rate of treatment showed some variation according to the number of teeth in crossbite with the highest success rate in subjects with 1 incisor in anterior crossbite. One incisor in anterior crossbite is generally easier to treat successfully than several incisors in anterior crossbite, mainly because the probability of skeletal Class III discrepancy increases with more incisors in crossbite, and therefore correction of skeletal anterior crossbite with removable appliances had rather poor prognosis in our study. In all unsuccessful cases, there was a remaining anterior crossbite of 1-2 incisors not including both central incisors post treatment.

Correction of a Class III molar relationship to a Class I or super Class I molar relationship was achieved in 2 successful cases, but mainly there were no changes in molar relationship, indicating that the treatment of anterior crossbite with removable appliances did not affect the molar relationship.

The results showed that maxillary crowding was somewhat more frequent in subjects with less than four incisors in anterior crossbite than in subjects with a full anterior crossbite. This observation may be caused by different etiologies. A full anterior crossbite is often associated with a skeletal discrepancy<sup>13</sup>. In cases with single anterior teeth in crossbite, the crowding itself might be the main etiological cause, since anterior crowding in the upper jaw often leads to palatal displacement of individual teeth, which may cause an anterior crossbite<sup>13</sup>.

Therefore, anterior crossbite may also reflect crowding of teeth, when there are only one or two incisors involved, not including both central incisors in the anterior crossbite.

The treatment was unsuccessful in 3 subjects, who showed clear Class III skeletal characteristics, which complicated the treatment, and was the likely reason for the unfavorable treatment response. Compliance, insufficient overbite post treatment, or choice of appliance could also have contributed to the failure. In 4 of the subjects there were an increase in the ANB angle after treatment with a retractor appliance. This indicates that treatment with a retractor appliance may



have some favorable skeletal effects in addition to the dental effects, though some of the changes can be contributed to the natural growth of the maxilla and the mandible. The inclination lower incisors/mandibular line decreased in all subjects after treatment with a retractor appliance, which means that the treatment retroclined the lower incisors, compensating the skeletal discrepancy. In cases with an anterior crossbite, an important determinant for stability of the treatment results is a positive overbite<sup>16</sup>. If a sufficient overbite is achieved, retention is theoretically not essential because the occlusion will maintain the result. In this study, the subjects with an equal or increased overbite post treatment may have a better prognosis in the long term as compared to subjects with a reduced overbite.

### **Treatment practices in relation to treatment outcome**

The results showed that there was a significant difference in duration of active treatment between subjects with a successful and unsuccessful treatment outcome, 7.4 and 14.4 months, respectively. This shows that the duration of treatment of unsuccessful subjects was nearly doubled. The number of appointments did not show difference, as the unsuccessful subjects in average only had 1.5 more appointments than the successful subjects. This means that the appointments in the unsuccessful group were distributed over a longer time span.

There can be different causes for the extended duration of treatment in the unsuccessful cases, but most likely this is connected to problems with compliance or difficulty of treatment. Examples of lack of compliance might be that the subjects did not show up for appointments or that the treatment continued over the summer. This insufficient follow-up hampers the possibility for the clinician to control the adjustments of the appliance and subjects' compliance, both of which affect the treatment outcome. When there was no success after expected duration of treatment, the treatment was not interrupted but instead continued a little longer. This can be because the operator expects the compliance to be the reason, or that the appliance has not been adjusted correctly, although the underlying reason might also have been the appliance because of the skeletal components of the anterior crossbite.

The removable appliances used at the student clinic to treat the subjects in this study were a retractor appliance with or without protrusion screw(s), an acrylic plate with protrusion screw(s), and an expansion plate with protrusion screw(s). The expansion plate was most often used, as many subjects had an anterior crossbite in combination with a posterior crossbite. The retractor appliance was used least often, because it was generally used only in subjects with a full anterior crossbite or both central incisors in anterior crossbite, who were in the minority in this study.

The success rates with retractor, acrylic plate and expansion plate were 57 %, 75 %, and 63 %, respectively. The retractor appliance showed the lowest success rate, while the acrylic plate showed the greatest success rate. Reasons for this might be that the retractor needs adjustment of the labial bow continuously to be effective, and because the retractor appliance was most often used in subjects with all four or both central incisors in anterior crossbite and often with a skeletal Class III tendency. The acrylic plate may be easier to use, needs little adjustment to be effective, and it was only used in subjects with 2 incisors in anterior crossbite not including both central incisors, which generally are less complicated to treat than a full anterior crossbite.

Compliance was not superior when the treatment started in the early mixed dentition compared to the late mixed and permanent dentition. The definition of compliance is relative, since there is no clear measurement for this variable. In this study, the compliance was divided into three distinct categories: excellent, acceptable and poor, and the subjects were assigned to the different categories based on the examiners' subjective opinions. Subjects in the excellent cooperation category showed no lack of compliance, while in contrast poor compliance was associated with broken, lost, or not used appliances, or missed appointments. Subjects in the acceptable category were considered to be in between these limits. The results showed that most subjects in the excellent category had a successful treatment outcome, while roughly only 2 out of 3 subjects ranked in the acceptable category showed treatment success. This is in accordance with previous reports, which have shown positive correlation between treatment success and patient compliance<sup>17</sup>. The category of poor compliance showed no successful cases. Even though this shows a clear

connection between compliance and success rate, there were only two subjects in the poor compliance category, which makes a weak foundation for comparison.

### **Challenges of treating patients at the student clinic in Tromsø**

The activities in the student clinic in Tromsø started gradually in 2007 and have been under development during the last 5 years. Therefore, the routines have not yet been fully established regarding documentation of patient treatments and evaluation of the results. An obvious drawback when several students and supervisors are involved in the same treatment is the big variation seen in the quality and quantity of pre-treatment and post treatment records. In this study, the pre-treatment records included more information than the post-treatment records. The clear shortcoming was the insufficient recording in the patients' journal in OPUS, both in the pre- and post-records. In general, all pre-treatment records were present with plaster models, clinical photos and x-rays, but very often information from these were not described in the records. Information from patient files, which often were not described, included teeth in anterior crossbite, family history of malocclusion, evaluation of profile and appliances of choice. Lateral cephalogram were often missing in pre-treatment records. Post treatment records were typically insufficient or missing, especially when the treatment was unsuccessful. This made evaluation of treatment outcome impossible in many cases. Therefore, nearly half of the subjects had to be invited to the student clinic only to get their post-treatment records completed to enable assessment of their treatment result. Inadequate records were probably due to absence of guidance, which specifies what the records should contain. Fractured teeth, not fully erupted incisors, or missing plaster models were the most frequent reasons for why the overjet was not measurable pre-treatment.

### **Conclusions**

Our results suggest that 2 out of 3 anterior crossbites were successfully corrected in the university student clinic in Tromsø, and longer treatment time seemed to affect the treatment success negatively. The common lack of post-treatment documentation calls for considerable improvement.

## Tables and figures

**Table 1: Typical diagnostic signs in differentiating between dento-alveolar and skeletal Class III**

	Dento-alveolar anterior crossbite	Skeletal anterior crossbite
Family history of Cl III	No	Yes
Angle Class in CR <sup>1</sup>	Cl I	Cl III
Angle Class in IP <sup>2</sup>	Cl I or III	Cl III
Incisor inclination	Upper incisors upright Lower incisors normal/labial	Upper incisors proclined Lower incisors retroclined
Anterior shift CR-IP	Yes	No*
Profile	Straight in CR Can be concave in IP	Concave

\*Skeletal Class III can be associated with anterior shift from CR to IP in the early mixed dentition.

<sup>1</sup> CR = centric relation, <sup>2</sup>IP = intercuspal position

**Table 2: Treatment success in relation to dental stage pre-treatment**

	Success		Total
	Successful	Not successful	
Dental stage Early mixed	17 (68 %)	8 (32 %)	25 (100 %)
Late mixed	4 (57 %)	3 (43 %)	7 (100 %)
Permanent dent	2 (100 %)	0 (0,0 %)	2 (100 %)
Total	23	11	34 (100 %)

$p = 0,519$

**Table 3: Treatment success in relation to the age at start of treatment**

	Success		Total
	Successful	Not successful	
Age 8-9 years	12 (57 %)	9 (43 %)	21 (100 %)
Age 10-12 years	11 (85 %)	2 (15 %)	13 (100 %)
Total	23	11	34 (100 %)

$p = 0,096$

**Table 4: Treatment success in relation with number of teeth in anterior crossbite**

	Success		Total
	Successful	Not successful	
Single incisor(s) in crossbite	14 (78 %)	4 (22 %)	18 (100 %)
Two or more adjacent incisors in crossbite	8 (57 %)	6 (43 %)	14 (100 %)
All four incisors in crossbite	1 (50 %)	1 (50 %)	2 (100 %)
Total	23	11	34 (100 %)

$p = 0,400$

**Table 5: Type of anterior crossbite in relation to crowding of the maxillary incisors**

	Crowding of maxillary incisors		Total
	Yes	No	
Single incisor(s) in crossbite	12 (67 %)	6 (33 %)	18 (100 %)
Two or more adjacent incisors in crossbite	8 (57 %)	6 (43 %)	14 (100 %)
All four incisors in crossbite	0 (0 %)	2 (100 %)	2 (100 %)
Total	20	14	34 (100 %)

$p = 0,189$

**Table 6: Mean values with ranges for different cephalometric parameters of the subjects (N=9) according to the cephalometric analysis.**

	SNA		SNB		ANB		Incl.up.inc/SN		Incl.lo.inc/ML		SN/ML		Interinc ang	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Range	70,7-86,3	74,9-87,5	72,3-86,6	73,0-88,9	-2,4-3,5	-3,2-4,1	92,8-121,3	99,5-125,9	84,4-113,4	79,4-109,6	21,4-45,1	20,3-42,8	105-137,2	107,1-139,2
Mean	78,9	81,2	78,6	81,7	0,4	-0,5	107,7	113,7	100,4	94,9	32,1	29,6	119,8	121,8
Norm values*	80-89		75-82		2-4		102 +/- 6		94 +/- 4,5		33 +/- 4		130-150	

\*Normal values according to Facad 3.5.0.3

**Table 7: Treatment success in relation to duration of the treatment**

	Success		Total
	Successful	Not successful	
Treatment time ≤8 months	21 (88 %)	3 (12 %)	24 (100 %)
Treatment time ≥9 months	2 (20 %)	8 (80 %)	10 (100 %)
Total	23	11	34 (100 %)

$p = 0,000$

**Table 8: Treatment success in relation to appliance used**

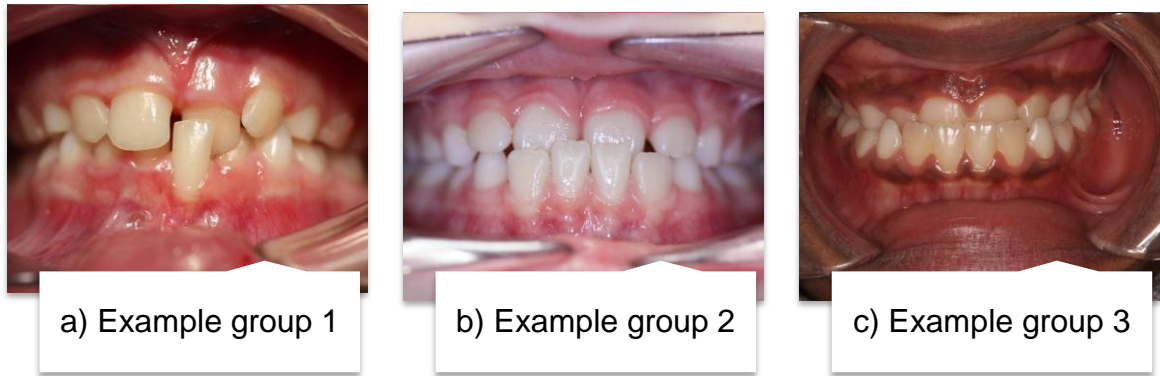
		Success		Total
		Successful	Not successful	
Appliance	Retractor	4 (57 %)	3 (43 %)	7 (100 %)
	Acrylic plate	7 (88 %)	1 (12 %)	8 (100 %)
	Expansion plate with protrusion	12 (63 %)	7 (37 %)	19 (100 %)
Total		23	11	34 (100 %)

$p = 0,374$

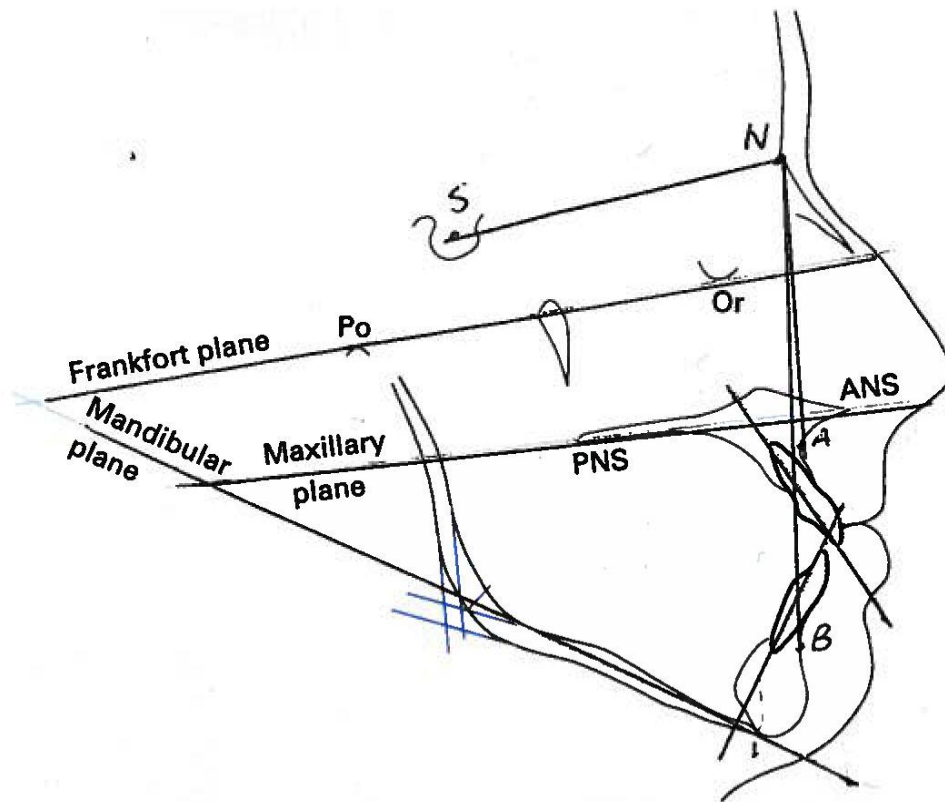
**Table 9: Patient compliance in relation to different appliances used**

	Appliance			Total
	Retractor	Acrylic plate	Expansion + protrusion plate	
Excellent	0 (0 %)	5 (36 %)	9 (64 %)	14 (100 %)
Acceptable	7 (39 %)	3 (17 %)	8 (44 %)	18 (100 %)
Poor	0 (0 %)	0 (0 %)	2 (100 %)	2 (100 %)
Total	7 (21 %)	8 (23 %)	19 (56 %)	34 (100 %)

$p = 0,056$



**Figure 1: Anterior crossbite groups**



**Figure 2: Cephalometric parameters used in the cephalometric analysis (picture adopted from L. Mitchell, 2007)**



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