

The National Dental Practice-Based Research Network Adult Anterior Openbite Study: Patient
Satisfaction with Treatment

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Abstract

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Introduction: This paper evaluates patient satisfaction of adults, who received orthodontic treatment for anterior openbite malocclusion across the United States. The factors that influence the satisfaction of these patients are also described. Methods: Practitioners were recruited from the National Dental Practice-Based Research Network. Upon joining the Network, practitioner demographics and information on their practices were acquired. Practitioners enrolled their adult patients in active treatment for anterior openbite. Patient demographics, patient dentofacial characteristics, and details regarding previous and current treatment were collected through questionnaires at enrollment (T1). Pre-treatment lateral cephalograms and intraoral frontal photographs were submitted. Treatment performed and details related to treatment outcome were recorded through questionnaires at the end of active treatment (T2). Post-treatment lateral

cephalograms and intraoral frontal photographs were submitted. Patient satisfaction at the end of active treatment (T2) was assessed using a five-point, Likert-like scale and open-ended responses. Predictive univariate models were developed to evaluate the factors that influence patient satisfaction. Open-ended responses were reviewed for general trends. Results: End of active treatment (T2) data was received for 256 patients. Two hundred forty-eight of these patients completed and returned the patient satisfaction questionnaires. High levels of satisfaction were found in our sample of adult patients receiving treatment for anterior openbite malocclusion. Specifically, 96% of the sample reported being very or somewhat satisfied. Only ten patients (4%) were not satisfied with the treatment provided or an element of the final result. Successful openbite closure, treatment modality, and certain patient characteristics may influence patient satisfaction. However, there was insufficient power to demonstrate statistical significance. Open-ended responses directly associated with patient satisfaction were received from twenty-three patients (9%). They relayed positive, neutral, and negative feelings about the treatment received and final results. Additional responses regarding the orthodontic treatment in general, but not specifically linked to patient satisfaction, were received from 119 patients (48%). These comments depict an overwhelmingly positive experience. Conclusions: Adult patients who received orthodontic treatment for anterior openbite malocclusion were generally satisfied with the treatment provided, as well as the final esthetic and functional results.

Introduction

Anterior openbite (AOB) was first described in the dental literature more than 150 years ago.¹ It can be defined as a lack of vertical contact and overlap of the anterior teeth in maximum intercuspation.²⁻⁴ The prevalence of AOB in the United States ranges from 0.6% to 16.5%, depending on age and race.⁵ The etiology of AOB is complex and multifactorial. Oral habits, unfavorable growth patterns, respiratory factors, and neuromuscular imbalance have been suggested to play a role.⁶ AOB often results in significant esthetic and functional concerns, including difficulty incising food and speaking.^{3,7,8}

AOB is widely considered to be one of the most challenging malocclusions to treat. In children with digit or tongue habits, AOB is often treated with behavior-modifying appliances. Standard, edgewise fixed appliances can be used to treat AOB of dental origin through the extrusion of incisors. Vertical elastics or extractions⁹ can also be integrated to aid bite closure. Severe AOBs of skeletal origin in non-growing patients have traditionally been treated with orthognathic surgery.¹⁰ Recently, temporary anchorage devices (TADs) and clear aligners have been suggested to treat AOB through the intrusion of posterior teeth. Although numerous strategies have been proposed to treat AOB cases, there is no consensus as to which is the preferred treatment modality for a particular case. Current evidence on the success of AOB treatment is based primarily on retrospective case series.¹¹ This literature only evaluates clinical outcomes. Patient satisfaction associated with treatment of AOB malocclusion has not been evaluated.

Over the past few decades, the healthcare literature has placed an increased emphasis on quality of life.¹² Improvement in quality of life is a fundamental goal of medicine and dentistry.¹³ Orthodontic treatment, specifically, aims to enhance oral health-related quality of life through the correction of malocclusion.^{14,15} As orthodontic treatment intends to improve a patient's dentofacial esthetics and oral function, it is important for orthodontic literature to evaluate patient-centered outcomes. Traditional, orthodontic outcome measures do not necessarily reflect patient values and, until recently, patient perspectives have received limited coverage in the orthodontic literature.^{12,16,17} In this report, we investigate satisfaction levels of adult patients after receiving orthodontic treatment for AOB malocclusion. We also describe the factors that are associated with satisfaction and dissatisfaction.

In 2015, the National Dental Practice-Based Research Network (PBRN) Adult Anterior Openbite Study was launched. The purpose of this large, prospective cohort study was to explore treatment recommendations, outcomes, and subsequent vertical stability of adult AOB patients. The study was divided into three phases: enrollment (T1), end of active treatment (T2), and 1-year post-treatment (T3). A prior publication characterizes the practitioners and patients enrolled in the study.¹⁸ Another previous publication details the factors that influence treatment recommendations.¹⁹ This paper describes patient satisfaction at the end of active treatment (T2). A concomitant publication addresses treatment success.²⁰

Materials and Methods

Providers were recruited from the National Dental PBRN, comprised of six geographic regions: West, Midwest, Southwest, South Central, South Atlantic, and Northeast. Institutional Review Board approval for this study was obtained from several institutions, representing the regions of the Network. These included the University of Alabama Institutional Review Board acting as the central Institutional Review Board, the Kaiser Permanente Northwest Institutional Review Board for the Western region, and the University of Rochester Research Subjects Review Board for the Northeast region.

Inclusion Criteria for Practitioners

- Orthodontist or dentist that routinely performs orthodontic treatment.
- Estimates to recruit three to eight adult patients in active treatment for AOB and expects to complete treatment within 24 months of enrollment into the study.
- Routinely takes cephalometric radiographs before and after treatment.
- Able to upload de-identified cephalometric radiographs and digital intraoral frontal photographs to a central data repository.
- Affirms that the practice can devote sufficient time in patient scheduling to allow recording of the required data.
- Does not anticipate retiring, selling the practice, or moving during the study.

Inclusion Criteria for Patients

- At least 18 years of age at the time of enrollment.
- Must have AOB, which is defined as one or more incisors that do not have vertical overlap with teeth in the opposing arch. The remaining incisors may have minimal incisor overlap, but cannot contact teeth in the opposing arch. This will be determined by examining the patient's initial cephalometric radiograph, intraoral photographs, and/or initial plaster or digital casts.
- Must be in active treatment for AOB and expects to have treatment completed within 24 months of enrollment in the study.
- Must have an initial cephalometric radiograph (taken prior to the beginning of treatment). A cephalometric radiograph created from a cone-beam CT scan is acceptable.

Exclusion Criteria for Patients

- Clefts, craniofacial conditions or syndromes.

- Significant physical, mental, or medical conditions that would affect treatment compliance, cooperation, or outcome.
- Expects to move before the completion of the study.
- Initial treatment plans estimated to be more than 36 months.

Recruitment was restricted to patients eighteen years of age or older to minimize the influence of facial growth on treatment outcome. To avoid selection bias, practitioners were requested to enroll all eligible patients. A maximum of 15 patients per practitioner was established. If a practitioner had more than 15 eligible patients, patients were selected sequentially based upon their treatment start dates.

Upon joining the Network, practitioner demographics and information on their practices were acquired. Patient demographics, patient dentofacial characteristics, and details regarding previous and current treatment were collected through questionnaires at enrollment (T1). Changes to treatment (i.e. added or removed procedures) and details related to treatment outcome were recorded through questionnaires at the end of active treatment (T2). Patient satisfaction was assessed using a five-point, Likert-like scale and open-ended responses at the end of active treatment (T2). Questionnaires were sent to regional centers, where they were reviewed for completeness and entered into a centralized database. More details on data collection from practitioners and patients can be found in a previously published paper.¹⁸ Study forms can be accessed at <http://nationaldentalpbrn.org/anterior-openbite-malocclusions-in-adults-recommendations-treatment-and-stability.php>.

Pre- and post-treatment lateral cephalograms and intraoral frontal photographs were uploaded to a centralized, Web-based system. De-identified images were forwarded to the research team at

the University of Washington. The radiographs were imported into Dolphin imaging software (version 11.0; Dolphin Imaging and Management Solutions, Chatsworth, Calif), landmarks were identified by two examiners, and an automated, custom cephalometric analysis was performed based on the selected landmarks. A depiction of the cephalometric landmarks can be found in Figure 1. Cephalometric landmarks were first identified by one examiner and then reviewed by the other examiner. Disagreements in landmark identification were resolved by means of consensus between the examiners.

A standard millimetric ruler in the lateral cephalogram was used to calibrate the millimetric measurements. If a ruler was absent, an estimate of the mesiodistal width of the mandibular first molar was used for calibration. A detailed description of this process can be found in a previous publication.¹⁸ This surrogate calibration method was validated by sensitivity analysis.

An index was developed to score the relative openbite severity using the intraoral frontal photographs. The Photographic Openbite Severity Index (POSI) has seven categories, defined by the type and number of teeth that do not have vertical overlap (Figure 2):

0. All four incisors with vertical overlap
1. One or two maxillary lateral incisors without vertical overlap (both maxillary central incisors have vertical overlap)
2. One maxillary central incisor without vertical overlap (the other maxillary central incisor has vertical overlap)
3. Both maxillary central incisors without vertical overlap (at least one maxillary lateral incisor has vertical overlap)
4. All four maxillary incisors without vertical overlap
5. All anterior teeth, including canines, without vertical overlap
6. All anterior teeth, plus at least one premolar, without vertical overlap

The intraoral frontal photographs were rated, independently, by the same two examiners.

Disagreements in POSI scores were resolved by means of consensus between the examiners.

Both examiners underwent training and calibration prior to landmarking lateral cephalograms and assessing intraoral frontal photographs. Ten lateral cephalograms and twenty intraoral frontal photographs were randomly selected to determine inter- and intra-rater reliability. The lateral cephalograms and intraoral frontal photographs were analyzed twice, one month apart, by both examiners. Inter- and intra-examiner reliability was assessed with an intraclass correlation coefficient. All values were greater than 0.90, indicating that landmark identification and POSI classification were reliable by examiner over time and between examiners.

Data Analysis

Outcome Variable

Patient satisfaction at the end of active treatment (T2) was assessed using a five-point, Likert-like scale: very satisfied, somewhat satisfied, neither satisfied nor dissatisfied, somewhat dissatisfied, very dissatisfied. Patients were asked to provide explanations following answers of somewhat or very dissatisfied. Satisfaction with the orthodontic treatment provided, satisfaction with esthetics, and satisfaction with function were evaluated separately. Whether or not treatment would be recommended to a friend with a similar malocclusion was also evaluated using a five-point, Likert-like scale: definitely recommend, probably recommend, undecided,

probably not recommend, definitely not recommend. Patients were asked to provide explanations following answers of probably or definitely not recommend.

Satisfaction rates were calculated by grouping responses: Satisfied (very satisfied and somewhat satisfied) vs. Not Satisfied (neither satisfied nor dissatisfied, somewhat dissatisfied, and very dissatisfied). Whether or not treatment would be recommended to a friend can be consider a proxy for patient satisfaction with the orthodontic treatment provided. The likelihood of this recommendation was also quantified by grouping responses: Would Recommend (definitely recommend and probably recommend) vs. Would Not Recommend (undecided, probably not recommend, and definitely not recommend). Open-ended responses were reviewed for general trends.

Predictors

Treatment Success

Patient-Perceived Treatment Success: at the end of active treatment (T2), patients were asked if their openbite was successfully closed

Practitioner-Reported Treatment Success: at the end of active treatment (T2), practitioners were asked if the openbite was successfully closed

Cephalometric Analysis

Lateral cephalometric radiographs were used to evaluate treatment success, defined by positive overbite at the end of active treatment (T2). Specifically, post-treatment lateral cephalograms were analyzed to determine if positive incisor overlap was achieved.

POSI

The POSI was used to evaluate treatment success, defined a score of 0 at the end of active treatment (T2).

Success can be defined by the four measures, described above. Patient-perceived and practitioner-reported treatment successes are subjective in nature. Treatment success defined by the cephalometric analysis only uses the most anterior maxillary and mandibular central incisors to calculate overbite, and therefore may not account for the vertical overlap of the other incisors. Alternately, the POSI scores the vertical overlap of all four incisors in maximum intercuspation. Preliminary analyses indicated that the POSI is the most discriminating measure to assess successful openbite closure (Appendix, Table 1).

Treatment Factors

Treatment Modality

Treatment modality was divided into four mutually exclusive categories:

1. ALN: aligners without fixed appliances, TADs, or orthognathic surgery
2. FA: fixed appliances without TADs or orthognathic surgery
3. TADs: TADs without orthognathic surgery
4. SX: orthognathic surgery

These categories represent an increasing ability to manage more complex malocclusions, as well as an increasing level of invasiveness. Patients treated with a combination of appliances were placed in the higher treatment category. For example, a patient treated with aligners and fixed appliances would be placed in treatment category #2. The final treatment categorization was thoroughly reviewed for accuracy and clinical validity. Review of clinical records was conducted, as needed. The effect of extractions on patient satisfaction was also explored.

Treatment Duration

Patient Characteristics: age, gender, race, insurance coverage, education level, previous orthodontic treatment

Practitioner Characteristics: age, gender, race, years in practice, geographic region of practice, practice type.

Univariate analyses were used to evaluate the influence of the aforementioned predictors on patient satisfaction. Statistical significance was adjusted for clustering of patients within practitioners using generalized estimating equations. Statistics were processed using PROC GENMOD in SAS with CORR=EXCH option. Due to the very small number of dissatisfied patients, only descriptive statistics could be performed.

Results

From October 2015 to June 2016, a total of 91 practitioners were recruited for the study. The practitioners enrolled 358 patients of whom 347 met the inclusion criteria.

End of active treatment (T2) data was received for 256 patients, treated by 84 different practitioners. Eighteen patients withdrew from the study. The remainder of the patients did not finish treatment within the study period. End of active treatment (T2) questionnaires were collected for 254 patients, of which 248 included patient satisfaction data. Post-treatment intraoral frontal photographs were received for 234 patients. Post-treatment lateral cephalograms were available for 231 patients. No differences were found between practitioner demographics at enrollment (T1) and those at end of active treatment (T2). Patients who completed treatment within the study period were older ($p = 0.04$) and more educated ($p = 0.04$) than those who did not. The pre-treatment openbite severity was similar for patients who completed treatment within the study period and those who did not.

The patients had a mean age of 31.2 years (SD = 11.9 years; range = 18-71 years). Seventy-five percent of the patients were female. Just over 40% of the patients had a previous history of orthodontic treatment. The practitioners had a mean age of 48.8 years (SD = 9.8 years; range = 31-66 years). Seventy-three percent of the practitioners were male. Of the practitioners, 82 were orthodontists and 2 were general dentists. Patient and practitioner demographics are presented in Tables 1 and 2. Detailed demographics, describing the patients and practitioners at enrollment (T1), can be found in a previously published paper.¹⁸

The mean pre-treatment overbite, measured using the lateral cephalograms, was -2.4 mm. All four incisors exhibited no vertical overlap ($\text{POSI} \geq 4$) in nearly two-thirds of the sample. Thus, most patients had significant AOBs prior to treatment.

Twenty-nine patients were treated only with clear aligners. One hundred fifty-two patients were treated with fixed appliances without TADs or orthognathic surgery. Twenty patients were treated with TADs without orthognathic surgery. Fifty-three patients were treated with orthognathic surgery. Extractions were performed in 49 patients. Treatment spanned an average of 24.8 months (SD = 11.3 months; range = 1-72 months). At the end of active treatment (T2), 84% of patients fell into POSI category 0, indicating that the openbite was successfully closed. For these successful cases, the mean post-treatment overbite was 1.6 mm (SD = 0.8 mm; range = -0.4-3.2 mm). Additional details on treatment success can be found in a concomitant publication.²⁰

Likert-Like Scales

High satisfaction levels were observed at the end of active treatment (T2). Specifically, two hundred thirty-five patients (96%) reported being satisfied with the orthodontic treatment provided as well as the final esthetic and functional results. Only ten patients (4%) were not satisfied with treatment or an element of the final result (Table 3). Four of these patients were not satisfied with multiple aspects of treatment. Nearly 98% of patients would recommend treatment to a friend with a similar malocclusion (Table 3). Likert-like scale responses to

satisfaction with the treatment provided, esthetics, and function are detailed, separately, in the following section (Appendix, Table 2).

Satisfaction with the Treatment Provided

Only one patient reported being dissatisfied with the orthodontic treatment provided. Two patients did not provide a response.

Satisfaction with Esthetics

Only one patient indicated being dissatisfied with the final esthetic result.

Satisfaction with Function

Five patients were neither satisfied nor dissatisfied with their ability to chew at the end of treatment. Two patients were dissatisfied with their ability to chew. Six patients were neither satisfied nor dissatisfied with their speech after treatment was completed. Two patients did not specify a response for each question related to function.

Due to the small number of dissatisfied patients, there was insufficient statistical power to investigate factors associated with patient satisfaction. Several trends were observed. First, patients who did not have a successful result were more likely to be dissatisfied (Table 4). The strength of this relationship varied with the measure of treatment success. Patients treated with clear aligners only or orthognathic surgery reported higher levels of dissatisfaction than those treated with other modalities (Table 5). Female patients were more than twice as likely to be dissatisfied with the orthodontic treatment provided or an element of the final results (Table 6).

Patients with a higher level of education were more likely to be dissatisfied (Table 6). No trends were observed between patient satisfaction and practitioner characteristics (Table 7). Compared to satisfied patients, dissatisfied patients were much less likely to recommend the treatment that they received to a friend with a similar malocclusion (Table 4). The 80% difference almost reached statistical significance.

Open-Ended Responses

Open-ended responses were received from two sources. Open-ended responses directly associated with patient satisfaction followed answers of somewhat or very dissatisfied on the Likert-like scale. Additional open-ended responses regarding the orthodontic treatment in general, but not specifically linked to patient satisfaction, were solicited separately. All open-ended responses were classified as positive, neutral, or negative. Neutral comments either indicate improvement with some minor reservations about the final result or do not provide any meaningful information.

Open-ended responses directly associated with patient satisfaction were received from twenty-three patients (9%). Only two of these patients were among the ten who indicated that they were not satisfied with the orthodontic treatment provided or an element of the final result. Both patients would not recommend the treatment that they received to a friend with a similar malocclusion. Available records, treatment details, and satisfaction results for these two patients are presented in Figures 3 and 4. The remaining twenty-one patients reported high levels of satisfaction. There were nearly equal numbers of positive, neutral, or negative responses from the twenty-one satisfied patients. The two dissatisfied patients primarily entered negative

comments, but also expressed some positivity. A representative sample of these open-ended responses is found in Table 8.

Additional open-ended responses regarding the orthodontic treatment in general, but not specifically linked to patient satisfaction, were received from 119 patients (48%). Five of these patients were among the ten who indicated that they were not satisfied with the orthodontic treatment provided or an element of the final result. The remaining patients reported high levels of satisfaction. Eighty-seven patients recorded positive responses. Of the positive responses, 56 mention the treatment received and 78 describe a positive doctor-staff-patient relationship. There were eleven negative and eighteen neutral comments for which no obvious trends were observed. Three patients expressed some concern about the stability of treatment. A representative sample of these open-ended responses is found in Table 9.

Discussion

Patient satisfaction with orthodontic treatment has received limited analysis in the orthodontic literature.^{16,17} Instead, most current orthodontic research reports on morphologic changes that result from treatment.¹⁶ Morphologic changes, obtained from analysis of casts, radiographs, and clinical examination²¹, are important and necessary for clinicians to evaluate treatment efficacy. However, these traditional outcome measures do not typically reflect patient values. As orthodontic treatment aims to improve a patient's dentofacial appearance, oral function, and

psychosocial state, it is important for orthodontic literature to evaluate patient-centered outcomes, such as patient satisfaction.^{12,16}

Extraordinarily high levels of patient satisfaction were found in our sample of adults, who received orthodontic treatment for AOB malocclusion across the United States. Specifically, 96% of the patients reported being satisfied with the treatment provided as well as the final esthetic and functional results. Only ten patients, out of the two hundred and forty-eight for whom satisfaction data was available, were not satisfied. The high satisfaction level is substantiated by the fact that 98% of the patients would recommend the treatment that they received to a friend with a similar malocclusion. Recommendation of treatment to a friend can be considered a proxy for overall patient satisfaction. The available literature on patient satisfaction describes high levels of contentment with orthodontic care.¹⁷

Numerous factors have been suggested to influence satisfaction with orthodontic treatment. A recent systematic review¹⁷ concluded satisfaction after orthodontic treatment was strongly associated with perceived esthetic outcomes, perceived psychological benefits of treatment, positive patient psychological traits, and the quality of the doctor-staff-patient relationship. Dissatisfaction after orthodontic treatment was correlated with increased discomfort or pain, problems with the usage of retention appliances, and negative patient psychological traits. Our results indicate that treatment outcome, treatment modality, and some patient characteristics may influence the satisfaction of adult, AOB patients. Statistical significance could not be assessed due to the small number of dissatisfied patients.

In our study, a direct relationship may exist between openbite closure and patient satisfaction. The relationship is strongest for patient-perceived treatment success and weakest when treatment success is defined by POSI = 0. The potential correlation between success and satisfaction is not surprising for several reasons. Adult patients tend to be more aware of their initial malocclusion and final treatment outcome.²² This natural awareness was likely heightened by their enrollment in the National Dental PBRN adult, AOB study. Two recent studies corroborate the close relationships between treatment outcome and patient satisfaction in adults. Reidmann et al.²³ found that 97% of adult patients were satisfied with their treatment outcome. Lee et al.²⁴ calculated an overall satisfaction rate of 84.9% and a 92.6% rate specifically related to treatment outcome.

The treatment modality may also affect the satisfaction of adult patients receiving treatment for AOB malocclusion. Patients treated with clear aligners only or orthognathic surgery report higher levels of dissatisfaction. Clear aligner therapy is the most esthetic and least invasive treatment modality. For these reasons, one may expect aligner patients to be exceedingly satisfied. On the contrary, patients who specifically request this esthetic treatment option may be more fastidious. Fastidious patients are more discriminating of the treatment and result, potentially substantiating the higher levels of dissatisfaction observed with aligner patients. A recent study described high levels of patient satisfaction with clear aligner therapy, however satisfaction was most strongly correlated to the doctor-patient relationship.²⁵ Another study found similar satisfaction levels between aligner therapy and conventional fixed appliances.²⁶ High levels of patient satisfaction have traditionally been reported after orthodontic treatment combined with orthognathic surgery.²⁷ Satisfaction is presumably due to the significant esthetic

and functional improvements produced by surgical correction. Conversely, dissatisfaction is often associated with functional impairment or dysfunction after surgery. This association was evident in the open-ended responses, as three of the fifty-three surgical patients (6%) described residual numbness and/or pain following the procedure. Overall, the possible inverse relationship between orthognathic surgery and satisfaction found in this study is likely due to the invasiveness of the procedure and the residual side effects following the procedure.

Trends were observed between satisfaction and two patient characteristics, namely sex and education level. Previous research has established that patient satisfaction is associated with sex. Specifically, female patients have higher expectations about dentofacial improvement and, in turn, are more critical of treatment.^{17,24,28,29} In the present study, female patients reported higher levels of dissatisfaction with the orthodontic treatment provided and the final result. Educated patients also tended to be less satisfied. Patients with higher education levels are more discriminating, which likely predisposes them to be dissatisfied with an aspect of treatment.³⁰

Open-ended responses provide valuable insight into patient perspectives. Following answers of somewhat or very dissatisfied on the Likert-like scale, patients were asked to specify the reason for their dissatisfaction. Interestingly, comments were only entered by two of the ten patients who were not satisfied with treatment or an element of the final result. This prevents us from fully understand their dissatisfaction. For example, a patient with a seemingly large functional change indicated that he or she was not satisfied with his or her ability to chew at the end of treatment (Figure 5). Instead, the vast majority of the responses were provided by patients who reported high levels of satisfaction.

Positive and negative open-ended responses were received from both satisfied and dissatisfied patients, regardless of whether their openbite was successfully closed. For example, a satisfied patient indicated that he or she “would like to have had the tiny gaps closed up”. The patient had a successful result. His or her comment referred to black triangles that developed following the alignment of overlapping incisors (Figure 6). This implies that the significant esthetic and functional improvements produced by AOB closure likely override minor discontent with treatment. Another patient was satisfied with an unsuccessful result. He or she reported being “totally happy”, as the openbite “was closed as much as possible” (Figure 7). In contrast, a different patient was dissatisfied with an unsuccessful result, stating that the residual openbite makes “it very difficult to eat and bite down on food” (Figure 3). Despite these functional concerns, the patient “was extremely satisfied with the office staff”. This distribution of responses suggests two principles. First, if practitioners set realistic expectations, patients are usually satisfied at the end of treatment.^{22,31} Second, satisfaction may be most closely associated with positive patient personality traits^{17,31,32} and a quality doctor-staff-patient relationship.^{17,28,29,33-37} The value of the doctor-staff-patient relationship was substantiated by additional comments, separate from those directly associated with patient satisfaction. These additional responses were overwhelmingly positive and clearly demonstrate the value of a positive patient-provider relationship.

Given the high levels of success²⁰ and patient satisfaction immediately following treatment, it will be extremely important to assess these outcomes in retention. Long-term patient satisfaction

with orthodontic treatment has been shown to be high.³⁸ It will be interesting to determine whether this is true for openbite patients, who have a high tendency for vertical relapse.¹¹

Limitations

This study has several limitations. The sample of practitioners was not randomly or consecutively chosen. Practitioners were recruited from the National Dental PBRN and some self-selection certainly occurred. These practitioners may have had a particular high interest or skill level in treating anterior openbite patients. Patients also were not randomly chosen, but steps were taken to minimize selection bias. Practitioners were asked to enroll all eligible patients in their practice, up to a maximum of fifteen. If a practitioner had more than fifteen eligible patients, patients were selected sequentially based upon their treatment start dates. Although the analysis was adjusted for clustering, a residual effect could remain and the quality of the doctor-staff-patient relationship has been shown to positively influence patient satisfaction.¹⁷ Also, about 70 of the 347 originally enrolled patients had not completed treatment at the time that data collection closed. There could be many reasons why these patients did not complete treatment during the study period, including more challenging malocclusions, poor cooperation, modifications to treatment plans, and refractory oral habits. It is possible that these patients may have a lower success rate than those who finished treatment during the study period, which might lessen the high satisfaction levels that we observed.

Although the study is prospective in design, details related to treatment were collected through questionnaires at enrollment (T1), after treatment had begun. As this data was acquired retrospectively, there is a risk for recall bias. Patient satisfaction was assessed immediately following debond. Patients placed completed questionnaires in sealed envelopes, allowing their responses to remain anonymous. However, as the satisfaction questionnaire was typically administered on the day of appliance removal, patients may not have had sufficient time to evaluate their satisfaction, specifically related to function. Additionally, high levels of satisfaction may be expected on the day of appliance removal. Finally, due to the high levels of satisfaction, there was insufficient power for inferential statistics.

Conclusions

Very high levels of satisfaction were observed for adult patients who received orthodontic treatment for AOB malocclusion. Although there were too few dissatisfied patients to conduct any meaningful statistical analyses, our results suggested that satisfaction may be associated with successful openbite closure, as well as treatment modality, gender, and education level.

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Figure Legends

Figure 1. Cephalometric landmarks identified on pre- and post-treatment lateral cephalograms: sella (S), nasion (N), anterior nasal spine (ANS), posterior nasal spine (PNS), pogonion (Pg), gnathion (Gn), menton (Me), anatomic gonion (Go), articulare (Ar), A-point (A), B-point (B), incisal edge of the maxillary incisor (U1 incisal edge), root tip of the maxillary incisor (U1 root tip), incisal edge of the mandibular incisor (L1 incisal edge), root tip of the mandibular incisor (L1 root tip), mesiobuccal cusp tip of the maxillary first molar (U6), mesiobuccal cusp tip of the mandibular first molar (L6).

Figure 2. Photographic Openbite Severity Index (POSI), developed to score the relative openbite severity using the intraoral frontal photographs

Figure 3. Pre-treatment records. Neither a post-treatment lateral cephalogram nor intraoral frontal photograph was received. The patient was treated with clear aligners, only. No other treatment modalities were recommended. At the end of active treatment (T2), the patient indicated that he or she was somewhat dissatisfied with the final esthetic result and very dissatisfied with his or her ability to chew. The patient would not recommend the treatment that he or she received to a friend with a similar malocclusion. Open-ended responses (Table 8) describe a residual openbite and difficulty incising food. Despite this result, the patient was “extremely satisfied with (the) office staff”.

Figure 4. Pre- and post-treatment records. With treatment, the overbite increased from -2.9mm to 0.1mm. The POSI score decreased from 2 to 1, signifying that the openbite was not successfully closed. The patient was treated with clear aligners, only. This was the primary recommendation. The practitioner also recommended full-fixed appliances and full-fixed appliances with TADs. At the end of active treatment (T2), the patient indicated that he or she was somewhat dissatisfied with the treatment provided and very dissatisfied with his or her ability to chew. The patient would not recommend the treatment that he or she received to a friend with a similar malocclusion. Open-ended responses (Table 8) describe improved esthetics, but elevated temporomandibular dysfunction symptoms. No statement was included about the residual openbite.

Figure 5. Pre- and post-treatment records. With treatment, the overbite increased from -2.5mm to 2.4 mm. The POSI score decreased from 6 to 0, signifying that the openbite was successfully closed. The patient was treated with full-fixed appliances and orthognathic surgery. Despite a successful result, the patient indicated that he or she was not satisfied with his or her ability to chew at the end of treatment.

Figure 6. Pre- and post-treatment intraoral frontal photographs. The openbite was closed and the patient was satisfied with treatment. However, the patient expressed minor misgivings about the final esthetics result, specifically the black triangles.

Figure 7. Pre- and post-treatment intraoral frontal photographs. The openbite was not successfully closed, but the patient was still satisfied with treatment. In his or her words, the openbite “was closed as much as possible”.

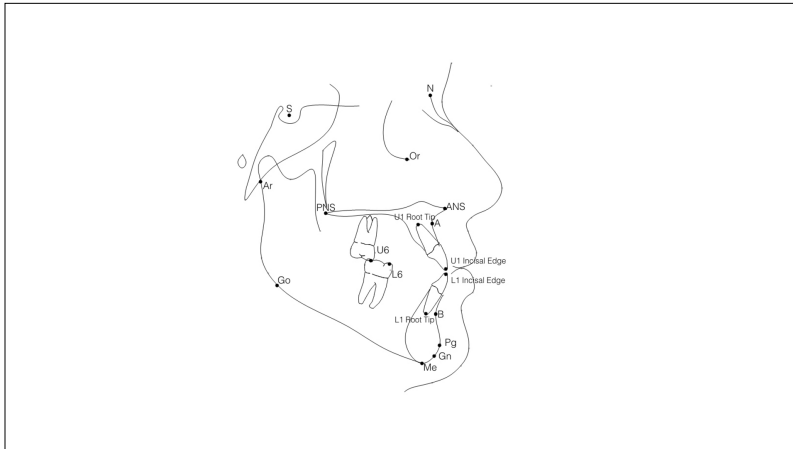


Figure 1



Figure 2



Figure 3

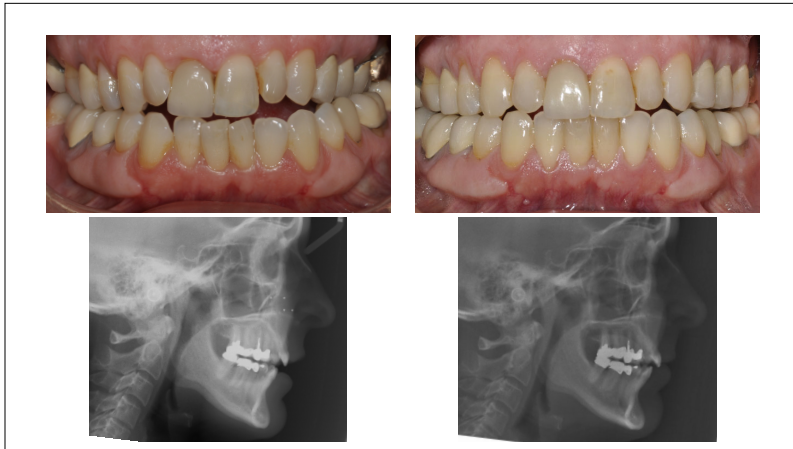


Figure 4

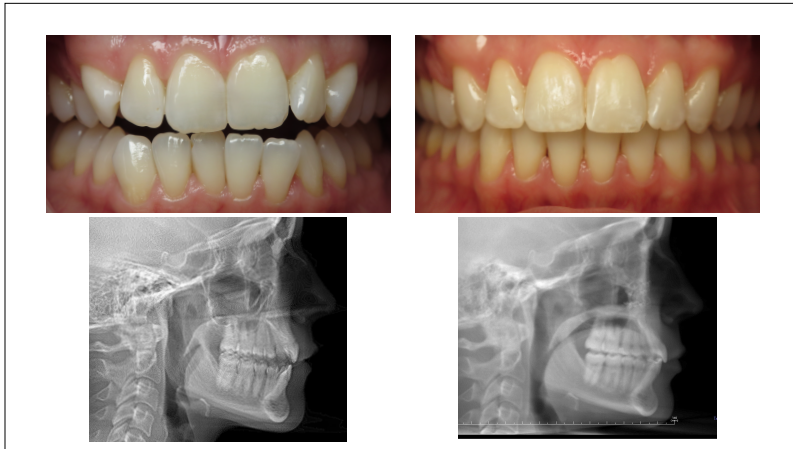


Figure 5



Figure 6



Figure 7

Table 1. Patient demographics

	N	%
<u>Sex (N = 253)</u>		
Male	64	25%
Female	189	75%
<u>Age, years (N = 253)</u>		
18 - 20	43	17%
21 - 30	106	42%
31 - 40	58	23%
≥ 41	46	18%
<u>Race and Ethnicity (N = 253)</u>		
White/Caucasian	146	58%
Black/African-American	23	9%
Asian	24	9%
Multirace	8	3%
Hispanic	52	21%
<u>Previous Orthodontic Treatment (N = 253)</u>		
Yes	106	42%
No	147	58%
<u>Insurance Coverage</u>		
None	54	21%
Yes - does not cover ortho or Og Sx	64	25%
Yes - covers ortho, but not Og Sx	74	29%
Yes - covers Og Sx	62	24%
<u>Education Level (N = 253)</u>		
High school graduate or less	45	18%
Some college or associate degree	79	31%
Bachelor degree	84	33%
Graduate degree	45	18%

* N = 254, unless indicated otherwise

Table 2. Practitioner demographics

	N	%
<u>Status</u>		
Orthodontist	82	98%
General practitioner	2	2%
<u>Sex</u>		
Male	61	73%
Female	23	27%
<u>Age, years</u>		
< 45	32	38%
45 - 54	24	29%
55 - 64	23	27%
≥ 65	5	6%
<u>Race and Ethnicity (N = 83)</u>		
White/Caucasian	52	63%
Asian	19	23%
Multirace	2	2%
Hispanic	10	12%
<u>Network Region</u>		
West	34	41%
Midwest	8	10%
Southwest	16	19%
South Central	6	7%
South Atlantic	9	11%
Northeast	11	13%

* N = 84, unless indicated otherwise

Table 3. Patient satisfaction and recommendation of treatment to a friend

	N	%
<u>Satisfied (N=245)</u>		
On all	235	96%
Not on all	10	4%
<u>Recommend Treatment (N = 246)</u>		
Would	240	98%
Would not	6	2%

Table 4. Recommend treatment and treatment success according to whether NOT satisfied on some aspect of treatment/result

			Recommend Treat		Patient: OB Closed		DDS: OB Closed		OB > 0mm		POSI = 0	
			No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
<u>Satisfied</u>			(N=6)	(N=240)	(N=11)	(N=236)	(N=20)	(N=228)	(N=16)	(N=211)	(N=38)	(N=190)
On all	235	96%	5	5	2	8	2	8	1	7	2	5
Not on all	10	4%	83%	3%	18%	3%	10%	4%	6%	3%	5%	3%
			p=0.056		p=0.2		p=0.4		p=0.4		p=0.4	

Table 5. Treatment performed according to whether NOT satisfied on some aspect of treatment/results

	ALL	Not satisfied	
	N=248	N=10	Row ² % p ³
<u>Primary Treatment Rendered</u>			
Aligners only	29	2	7%
Fixed appliances, no TADs or surgery	148	4	3%
TADs, no Surgery	20	0	0%
Surgery	51	4	8%
<u>Surgery</u>			
No	197	6	3%
Yes	51	4	8%
<u>Extractions</u>			
No	202	10	5%
Yes	46	0	0%
<u>Treatment Duration, months</u>			
< 17	56	3	5%
17 - 22	55	1	2%
23 - 29	72	2	3%
≥ 30	61	4	7%

¹Percents are "row" %s, namely, the proportion of the "outcome" treatment (column heading) for that treatment comparison.

² P-values are adjusted for clustering of patients within practitioners using generalized estimating equations

³ NE: Not estimable

Table 6. Patient demographic characteristics according to whether NOT satisfied on some aspect of treatment/results

	ALL		Not satisfied	
	N=248	N=10	Row ² %	p ³
<u>Sex</u>				
Male	63	1	2%	
Female	184	9	5%	
<u>Age, years</u>				
18 - 20	39	1	3%	
21 - 30	105	5	5%	
31 - 40	57	3	5%	
≥ 41	46	1	2%	
<u>Race and Ethnicity</u>				
White/Caucasian	143	7	5%	
Black/African-American	21	0	0%	
Asian	24	1	4%	
Multirace	8	1	12%	
Hispanic ethnicity	51	1	2%	
<u>Insurance Coverage</u>				
None	54	2	4%	
Yes - does not cover ortho or Og Sx	63	5	8%	
Yes - covers ortho, but not Og Sx	72	1	1%	
Yes - covers Og Sx	59	2	3%	
<u>Education Level</u>				
High school graduate or less	40	1	2%	
Some college or associate degree	79	1	1%	
Bachelor degree	84	4	5%	
Graduate degree	44	4	9%	
<u>Prior Orthodontic Treatment</u>				
No	144	5	3%	
Yes	103	4	4%	

¹Percents are "row" %, namely, the proportion of the "outcome" treatment (column heading) for that treatment comparison.

² P-values are adjusted for clustering of patients within practitioners using generalized estimating equations

³ NE: Not estimable

Table 7. Practitioner/practice according to whether NOT satisfied on some aspect of treatment/results

	ALL	Not satisfied		
	N=248	N=10	Row ² %	p ³
<u>Country Trained In</u>				
United States	203	8	4%	
Other	45	2	4%	
<u>Sex</u>				
Male	179	8	4%	
Female	69	2	3%	
<u>Age, years</u>				
< 45	100	4	4%	
45 - 54	59	1	2%	
55 - 64	73	4	5%	
≥ 65	16	1	6%	
<u>Race and Ethnicity</u>				
White/Caucasian	148	6	4%	
Asian	70	2	3%	
Hispanic	24	1	4%	
Multirace	6	1	17%	
<u>Years Since Dental Degree</u>				
< 10	22	2	9%	
10 - 19	98	2	2%	
20 - 29	65	2	4%	
≥ 30	62	4	6%	
<u>Practice Type</u>				
Solo, private practice	112	8	6%	NE
Owner, non-solo private practice	52	1	2%	
Associate/employee, private practice	24	0	0%	
Preferred provider practice	12	2	8%	
Academic setting	46	2	4%	
<u>Network Region</u>				
West	121	5	4%	NE
Midwest	24	2	8%	
Southwest	28	2	7%	
South Central	11	0	0%	
South Atlantic	30	0	0%	
Northeast	34	1	3%	

¹Percents are "row" %s, namely, the proportion of the "outcome" treatment (column heading) for that treatment comparison.

² P-values are adjusted for clustering of patients within practitioners using generalized estimating equations

³ NE: Not estimable

Table 8. Representative sample of open-ended responses directly associated with patient satisfaction

Treatment Provided	Appearance	Biting and Chewing	Speech
Honestly, I wish my lower jaw was further forward, but that's vanity. My teeth look great! I'm very happy!			
		Biting with front teeth is still not able to fully bite thru things [sic], but much better,	
Doctor and his staff are wonderful and give high quality treatment [sic]. They are also very personable.	My teeth/bite look amazing and now I can comfortably smile.	I can chew/bite very comfortably with no issues.	I feel like it's more clear.
	They are almost too perfect.		
	Due to the appearance of my two front upper teeth, we could not align them 100% straight [sic]. Out of our control.		
The openbite is a lot smaller than before.			
		Still have lingering numbness and lower jaw cant is very slightly tilted [sic].	
	Would like to have had the tiny gaps closed up.		
	The staff were willing to experiment & do all that they could [sic]! I was extremely satisfied with office staff. The results did not meet my expectations. I still have openbite & pressure on back teeth.	It is very difficult to eat and bite down on food.	
Front teeth still do not touch bottom teeth [sic].	Front jaw moved forward more than anticipated [sic].		
	Slightly imperfect center alignment.		
	They look great! It seems like maybe there's still a little space between my teeth on the right where they removed my baby tooth, but that's probably b/c I was inconsistent about wearing the bands [sic].		
	Tipping/flaring of the tooth is a little more than expected [sic], but I'm still very happy with my teeth!		
		There is still occasional discomfort in my jaw.	
Jaw clicking is worse.	Appearance has improved, but jaw clicking is worse.	Jaw clicking is worse. I need to avoid any	Speech has not

		chewy foods (i.e. bread) [sic].	changed.
I can now eat raw vegetables, including lettuce.			

Table 9. Representative sample of open-ended responses regarding the orthodontic treatment in general, but not specifically linked to patient satisfaction

General Open-Ended Responses
Everything worked out great!
I'm very happy with my results. My bite feels amazing and now I can smile with confidence.
Dr. X and staff were (and continue to be) wonderful! All aspects of these past 9 months was above expectations [sic]!
I am extremely please with my results. They are life changing! I never dreamed my teeth would look this great! I now have a smile I wont be embarrassed of [sic]!
The process was smooth. Staff is great [sic]. I have already referred a friend that got his braces on [sic].
Dr. X and his staff are amazing!
Interested to see how long it is maintained.
Awesome experience. Great doctor.
Very satisfied. Very professional staff and doctor.
Dr. X and her team are top notch! Extremely satisfied with my results!
Would have like a more thorough explanation of the treatment plan at each appointment [sic].
I couldn't have asked for better treatment or a better team than Dr. X and his staff. Thank you!
The jaw surgery part of the treatment was quite intense and I don't quite have normal feelings back yet, but it continues to progress and the ortho experience was pretty normal.
I'll bet I had the best orthodontist out there! Loved the treatment, fantastic work and results!
Very happy that I completed the course, had the surgery, and Dr. X was awesome.
The only concern that I have is the possibility of my teeth moving out of alignment.
My orthodontic treatment was lengthy but well worth it. My orthodontists were very thorough and cared about my opinion and overall outcome of my teeth.
Excellent care at all times! Thank you!
Satisfied with the result! I would definitely recommend!
The entire staff was very nice and was always able and willing to answer questions about treatment.
Teeth shifting and developing openbite even with regular retainer wear and speech therapy to correct tongue thrust.
Over great service and staff.
This is one of the best decisions I've ever made. To get a new smile is all that I've wanted and the staff is wonderful here. They make me feel like family.
Very happy with the results! Can bite/tear food with my teeth!

Appendix, Table 1. Treatment success by measure

	Success Rate (%)
Patient-Perceived Treatment Success	95.6
Practitioner-Reported Treatment Success	91.3
Cephalometric Analysis (OB > 0mm)	93.1
POSI = 0	83.6

Appendix, Table 2. Raw patient satisfaction data

	N
<u>Treatment Provided (N = 246)</u>	
Very	227
Somewhat	18
Neither	0
Dissatisfied	1
<u>Appearance</u>	
Very	221
Somewhat	26
Neither	0
Dissatisfied	1
<u>Biting and Chewing (N = 246)</u>	
Very	205
Somewhat	34
Neither	5
Dissatisfied	2
<u>Speech (N = 246)</u>	
Very	221
Somewhat	19
Neither	6
Dissatisfied	0
<u>Recommend Treatment (N = 246)</u>	
Definitely	222
Probably	18
Undecided	4
No	2

* N = 248, unless indicated otherwise