The Influence of Patient, Practitioner, and Dentofacial Characteristics on Recommendations and Acceptance of Treatment Plans for Anterior Open Bite in Adults

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Abstract

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Introduction: A wide variety of treatment modalities have been employed over the years to treat anterior open bite (AOB) in adults, but there is little reliable evidence to support the primacy of any particular method. Additionally, we know very little about how patient factors affect clinical decision making for adult AOB. The purpose of this study is to explore how practitioner, patient, and dentofacial characteristics are associated with treatment decisions in adult AOB treatment across the United States. **Methods**: Study participants were recruited from the practices of National Dental Practice-based Research Network dentists. Participants consisted of practitioners and their adult patients in active treatment for AOB that met the inclusion/exclusion criteria. Practitioners completed questionnaires including questions about demographics, preferred techniques for treating open-bites, and study patient dentofacial characteristics. Patients were given a questionnaire that asked about chief complaints, treatment goals and expectations, and reasons for selecting a treatment plan. Initial pre-treatment cephalograms were collected for each patient and were traced to obtain patient dentofacial characteristics. The association of each of the dentofacial, patient, and practitioner characteristics with different treatment recommendations were ascertained using Chi-square tests for categorical variables and Wilcoxon rank-sum tests. For patient cephalometric variables (including OB, SN-MP, ANB), ANOVA was performed. For the dentofacial domain, logistic regression analyzed the dichotomous outcome of surgery most recommended treatment plan vs. no surgery. **Results:** A total of 68 practitioners and 199 adult patients participated in the investigation. A statistically significant mean difference was detected among practitioners prescribing TADs based on where they attended dental school (36% foreign trained recommend TADs often vs. 5% US trained, p=0.002) and based on their race (5% Caucasian providers “often prescribe” TADs, while 24% of Asian practitioners “often prescribe”; p=0.03). Patient acceptance was not associated with age or education level but was influenced by insurance coverage. When a patient did not have medical insurance that covered surgical costs, the acceptance rate for a surgical plan was much lower (47.7%) than when they did have coverage for the procedure (78.6%, p=0.009). Mandibular plane angle, initial overbite, and molar classification were all independently associated with a surgical recommendation. **Conclusions:** This study found several interesting associations between practitioner, patient, and dentofacial characteristics and treatment recommendations.

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Chapter 1. INTRODUCTION

The term "open-bite" has existed in the dental literature as a distinct form of malocclusion for over 150 years [1]. Since it was first described however, the definition of an open-bite has undergone several changes. Some have described anterior open-bite (AOB) as an incisal relationship that is shallower than "normal" in the vertical dimension, while others have more strictly defined it as the complete absence of positive overbite between the anterior teeth [2]. In this paper, the term AOB will be defined as *a lack of vertical overlap between one or more incisors in opposing arches when the patient is biting in maximum intercuspation.*

The reported incidence of AOB varies in the literature from 0.6% to 11% of the population, depending on how the authors have defined it [3]. Prevalence of AOB may vary with ethnicity. Studies have calculated a prevalence of 3.5% AOB in Caucasian children, while estimates for children of African descent may be as high as 16.5% [4, 5]. Despite its low prevalence, orthodontic demand for the treatment of AOB is relatively high. It has been estimated that approximately 17% of orthodontic patients have an anterior open-bite [6,7].

Depending on the severity, AOB can have significant functional and psychological effects on an individual [5,8,9]. Persons with large open bites may have difficulty incising food. They may also have trouble with speech due to altered tongue positioning on the anterior hard palate or incisors. AOB can affect the production of the phonemes /t/, /d/, /n/, and /l/. AOB is also associated with disturbances in production of the "s" sound and those with AOB may have a concomitant lisp[10,11,12]. Individuals with AOB are also reported to be at a greater risk for developing psychological problems, such as low self-esteem and social anxiety, when compared to those with normal occlusions [13].

Several etiologic agents have been associated with the development of an anterior open bite. One of the major factors that may contribute to an open-bite is the presence of a behavior that obstructs the eruption of the anterior teeth. These habits include non-nutritive sucking habits, such as on a thumb, finger or pacifier, and biting habits, such as repetitively chewing on a pen[4,5,14]. Abnormal tongue function and posture is also frequently cited as a common etiologic factor in anterior open-bite. Although controversial, most authors now believe that a tongue thrust is a learned adaptation to swallow effectively with an open-bite and does not deliver enough continuous force to be the causative agent. On the other hand, forward tongue posture at rest is thought to deliver a more continuous force to the dentition and is much more likely to be a direct etiologic factor in open-bite malocclusion[4, 5]. In addition to habit-related forces, AOB has been correlated with divergent maxillo-mandibular skeletal growth patterns. Divergent skeletal configurations may be derived from a patient's genetic growth pattern or from progressive condylar resorption[15]. Skeletal divergence has also been associated with conditions that affect the way the oral musculature behaves in equilibrium with the dentition. Nasopharyngeal airway obstruction, for example, has been linked to development of a long face and an open bite. Airway obstruction may be the result of allergies, enlarged tonsils, excessive adenoid tissue, or abnormalities of the turbinates, septum, and external nasal architecture[4, 5]. Less commonly, skeletally divergent open bites are associated with neurologic deficits such as tactile hypesthesia or cerebral palsy[16]. In general, there is controversy over the exact cause and effect relationships between these various factors, but it is agreed that the etiology of open-bite malocclusion is often multifactorial in nature[5, 17].

AOB is generally grouped into two broad categories that are assumed to be etiologically distinct from one another: dental open-bite and skeletal open-bite[18]. Many open bites, however, have elements of both skeletal and dental dysplasia[17]. Dental open-bites do not demonstrate any distinguishing craniofacial malformations and the lack of incisal overlap is believed to result from obstructed eruption of the anterior teeth[16]. Skeletal open bites, on the other hand, display a constellation of unique craniofacial signs in addition to the open-bite. Key features include normal or even excessive eruption of anterior teeth, excessive eruption of posterior teeth, a tipped palatal plane that is higher anteriorly, an accentuated curve of the maxillary occlusal plane and/or a reverse curve of the mandibular occlusal plane [19,16]. Vertical dentoalveolar excess is most commonly seen in the maxilla, less frequently in the mandible, and rarely in both jaws. Skeletal open-bite patients have normal or decreased ascending ramus heights and downward rotation of the mandible with a typical hyperdivergent or “long” face[20].

Closure of AOB is difficult to achieve and high rates of relapse are of primary concern to practitioners[21,22]. Many different strategies for treatment have emerged in an attempt to find stable treatment options that address different perceived etiological factors. Generally speaking, four treatment strategies are employed to treat anterior open bite: observation/advice on stopping early habits (such as digit habits), interceptive treatment, dentoalveolar tooth movement with orthodontic appliances and/or miniscrews, and maxilla-mandibular surgery[2,4].

The treatment of AOB in children tends to be more straightforward and predictable than treatment in adults. With children, habit intervention can often be employed before growth and eruption processes have ceased. In these cases, conservative intervention with interceptive appliances or myofunctional therapy may improve the clinical picture or completely resolve the AOB[23]. In fact, some preadolescent AOB cases may show spontaneous remission; in one cross sectional study of 1408 Navajo children, Worms demonstrated that as one moved up in age groups, 75 to 80% of children had marked improvement without any form of treatment [24]. Active treatment strategies for closing open bites in children may include habit appliances (e.g., tongue cribs, spurs), partial fixed appliances, high pull headgear or bite blocks to intrude posterior molars, vertical chincups, or functional appliances such as the Frankel-4[25].

In adults, the major growth potential of the patient has been completed, functional patterns are well-established, and the malocclusion will usually not resolve spontaneously. To correct adult AOB, both surgical and non-surgical methods have been employed. Non-surgical approaches for AOB may emphasize either intrusion of the posterior dentition or extrusion of the anterior dental units depending on whether the patient displays posterior vertical maxillary excess or under eruption of the anterior dentition. In cases where extrusion of incisors is desired, vertical anterior elastics and/or extrusion archwires can be used to assist in bite closure. Alternatively, multiloop edgewise archwires can be employed to alter the occlusal plane by uprighting teeth[2 26]. Clear aligners have also been suggested for use in controlling anterior open-bites because the double thickness of the clear plastic appliances on the occlusal surface is thought to exert an intrusive force on the posterior teeth while attachments and elastics can be used to create extrusive mechanics on anterior teeth[23]. Skeletal anchorage has also been used successfully to intrude posterior teeth and aid in bite closure [27 ,28, 29]. Several authors have even demonstrated that mini-plate molar intrusion can be used for severe open-bite patients with greater than 5.0 mm of open-bite, which was previously considered to be an indication for orthognathic surgery[27]. Non-surgical orthodontic treatment can also be performed with or without dental extractions. Extractions of first premolars have been utilized in the management of AOB for its “drawbridge effect,” whereby overbite is increased by retroclining and relatively extruding both upper and lower incisors during dental retraction[30]. Alternatively, second premolars or molars can be extracted to take advantage of the so-called “wedge effect.” The wedge effect theory postulates that, as posterior teeth move forward into the extraction space and the "posterior wedge" is removed, the bite will close more in the anterior segment than in the posterior segment[31].

Non-surgical orthodontic treatment is generally most suitable for dental AOB, while surgery may be a good option for skeletal open-bites[20]. However, many patients with skeletal open-bites may decline surgical treatment and instead seek conventional orthodontic treatment. In the meta-analysis by Greenlee *et al*, it was in fact noted that, apart from age, pre-intervention open-bite and other patient characteristics were remarkably similar across surgical and nonsurgical patients in the included studies[21]. Various surgical patterns can be used to close the bite, and surgical selection depends on the underlying skeletal dysplasia. Historically, maxillary impactions and bimaxillary osteotomies were popular methods to treat AOB [32,33]. However, these surgical patterns can have adverse soft-tissue effects and can lead to extrusion of the maxillary incisors during leveling and alignment. To avoid undesirable maxillary soft tissue and dental effects, mandibular bilateral sagittal split osteotomy (BSSO) with surgical closing rotation has become a viable alternative for patients with favorable soft tissue esthetics [34]. BSSO is particularly appealing for use in patients who have a coexisting anteroposterior skeletal dysplasia.

Although a wide variety of treatment modalities have been employed over the years to improve AOB, there is little reliable evidence in the literature to support the primacy of any particular method. Unfortunately, there are few long-term follow up studies on treatment of AOB, and those that exist have small sample sizes and lack controls to demonstrate the efficacy of the intervention. In addition, past studies have been mostly case series where patients receive one form of treatment so that inferences cannot be made about the comparative effectiveness of alternative treatments [21]. Thus, although many treatment options are available, an ideal therapeutic strategy has not been universally agreed upon for the treatment of various types of adult AOB. Clinical decision-making may be difficult for borderline patients, such as older adolescents with AOB or adults with mild to moderate AOB [21]. The motivation and rationale for suggesting certain treatment options for AOB has been largely unexplored and there is little information available on how and why practitioners across the United States are making treatment decisions for patients with this malocclusion. Likewise, we know very little about the interplay of patient factors in the clinical decision making process for adult AOB. Some authors have attempted to intuit patient motivation in selecting or rejecting specific plans. For example, Sherwood states that the scope, risk, and cost of an osteotomy may drive some patients and orthodontists away from surgical options for the treatment of AOB [20]. However, patient values and perceptions have never been directly measured regarding adult AOB treatment. Gathering information on patient values is essential when operators and patients make shared decisions on care and valuable information about an intervention can be overlooked by neglecting to measure outcomes important to patients [34].

To date, an assessment of the patterns of practitioner recommendation and patient treatment plan acceptance has not been performed. The purpose of this study is to explore how various practitioner, patient and dentofacial characteristics are associated with the treatment decisions being made in adult AOB cases across the United States today. In this study, we sought to answer the following questions:

<u>Practitioner Demographic Questions:</u>

1. How does a practitioner's experience (in years since graduation) affect their likelihood of recommending a particular treatment modality?

2. Does the practitioner's location (by region and urbanicity) affect their likelihood of prescribing a specific treatment modality?

Patient Demographic Questions:

1. Does the age of the patient influence their acceptance rate of particular treatment plans, such as extraction or surgery?
2. Does the patient's insurance coverage affect whether they accept a surgical orthodontic plan?
3. Does the education level of the patient influence their acceptance rate of specific treatment options?

Patient Dentofacial Questions:

How do the following patient dentofacial characteristics influence the likelihood of a practitioner recommending a particular treatment plan?

a. Mandibular plane angle
b. Severity of AOB
c. AP skeletal discrepancy
d. Crowding

Chapter 2. MATERIALS AND METHODS

Study participants were recruited from the practices of National Dental Practice-based Research Network dentists (National Dental PBRN). Providers were recruited from six different regions across the country to provide national representation. These regions have been defined by the National Dental PBRN as: West, Midwest, Southwest, South Central, South Atlantic, & Northeast (Table 1). A total of 68 practitioners were enrolled, the majority of whom were orthodontists (Table 2). Study participants consisted of these practitioners and their adult patients in active treatment for AOB that met the following inclusion and exclusion criteria:

Inclusion criteria:

1. Orthodontist is enrolled in the National Dental PBRN.
2. Patients are at least 18 years of age.
3. Enrolled patients have an anterior open bite as defined by the presence of one or more incisors that do not have vertical overlap with the teeth in the opposing arch. The remaining incisors may have minimal overlap but cannot have contact.
4. Patients are in active orthodontic treatment.

Exclusion Criteria:

1. Pre-intervention radiograph is non-diagnostic.
2. Pre-intervention radiograph is not available.
3. Patient has a history of clefts, craniofacial anomalies or syndromes affecting the face.
4. Patient has a significant physical or mental condition that would affect their ability to complete a questionnaire accurately.

TABLE 1. Practice Demographics

	Number (Percent)
Practice Type	
Solo, Private Practice	37 (55%)
Owner, Non-Solo, Private Practice	16 (24%)
Associate/Employee, Private Practice	7 (10%)
HealthPartners/Permanente Dental Associates	0 (0%)
Federal Government, Academic, Other Managed Care	7 (10%)
Practice Location	
Inner City or Urban Area	13 (20%)
Urban (not Inner City)	24 (36%)
Suburban	22 (33%)
Rural	7 (11%)
Geographic Region of Practice	
West (AK, AS, CA, CO, GU, HI, ID, MT, NV, MP, OR, UT, WA, WY)	30 (44%)
Midwest (IL, IN, IA, MI, MN, NE, ND, OH, SD, WI)	2 (3%)
Southwest (AZ, KS, NM, OK, TX)	14 (21%)
South Central (AL, AR, KY, LA, MS, MO, TN, WV)	5 (7%)
South Atlantic (FL, GA, NC, SC, VA)	6 (9%)
Northeast (CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, PR, RI, VI, VT)	11 (16%)

TABLE 2. Practitioner Demographics

	Number (Percent)
Specialty	
Orthodontist	65 (96%)
General Practitioner	3 (4%)
Age	
<45 years	25 (37%)
45-54 years	21 (31%)
55-64 years	16 (24%)
65 years <	6 (9%)
Sex	
Male	46 (68%)
Female	22 (32%)
Years in Practice	
<10 years	7 (10%)
10-19 years	25 (57%)
20-29 years	19 (28%)
30+ years	16 (24%)
Race	
White/Caucasian	40 (60%)
Asian	17 (25%)
Multi-Race	2 (3%)
Hispanic	8 (12%)

The population was restricted to adults to eliminate the potentially confounding variable of facial growth. Since open-bites are relatively rare, participating orthodontists were encouraged to enroll all of their adult open-bite patients in active treatment. It was also thought that more inclusive enrollment would help to prevent selection bias on the part of the orthodontist.

A description of the study, informed consent form, and questionnaires were provided to orthodontists and their patients that fit the inclusion criteria. Patients were reimbursed for each phase of the study they participated in; $25 for the first phase, $25 for the second phase, and $50 for the 3rd phase, for a total of $100 for all 3 phases. Practitioners were reimbursed $100 per enrolled patient per phase of the study ($300/patient total). Questionnaires were pilot tested on dental specialists before final versions were distributed to study participants. Each practitioner was asked to fill out a practitioner characteristics form when enrolled to participate in the study, which included questions about demographics and their preferred techniques for treating dental and skeletal open-bite patients. AOB subjects that met the inclusion criteria were invited to participate in the study at their regular adjustment visits, or alternatively, were invited over the phone by the regular office staff. Once a patient was enrolled, the orthodontist was asked to complete an information form for each patient, providing patient demographics, chief complaint, goals and expectations, prior treatment, treatment options recommended, and the final treatment plan accepted. Orthodontists were also asked about patient dentofacial characteristics, such as pre-intervention spacing, crowding, angle classification, cross-bites, and habits. At the time of enrollment, patients were given a questionnaire that asked about their chief complaints, treatment goals and expectations, and reasons for selecting a certain treatment plan. Once participants completed the questionnaires, they were collected centrally, and National Network staff entered all data.

In addition to the questionnaires, initial digital pre-treatment cephalograms were collected for each patient and forwarded to the research team at the University of Washington. Once de-identified, cephalograms were obtained, landmarks were identified and measurements were performed automatically using a custom analysis in Dolphin imaging software (version 11.0; Dolphin Imaging and Management Solutions, Chatsworth, Calif). Cephalometric landmarks were identified by a single experienced examiner (JK) at the University of Washington and subsequently reviewed by a second examiner (KW). Disagreements over cephalometric landmark identification were resolved by means of a consensus between the two examiners. Both examiners underwent training and calibration prior to identification of landmarks on the study images. Additionally, a random selection of 10 lateral cephalograms from the study pool was digitized twice, one month apart, by both examiners to determine inter and intra-rater reliability. Inter and intra-examiner reliability was assessed with an intra- class correlation coefficient (ICC). All values were greater than 0.90, indicating that tracings were reliable both by one practitioner over time and between practitioners.

The standard orthodontic landmarks that were identified in order to assess pre-intervention skeletal characteristics included the following points (Figure 1): sella (S), nasion (N), anterior nasal spine (ANS), posterior nasal spine (PNS), gnathion (Gn), menton (Me), articulare (Ar) anatomic gonion (Go), constructed gonion (*Go*), the incisal edges of the maxillary and mandibular incisor teeth, the cusp tips of the maxillary and mandibular first premolars and the mesiobuccal cusp tips of the maxillary and mandibular first molars.

The following reference lines were used: S–N, Palatal Plane ((PP); ANS-PNS), Inferior border of the mandible (*Go*–Me), and Occlusal plane (intersection MB cusp tips first molars to intersection incisal edge incisors=OP).

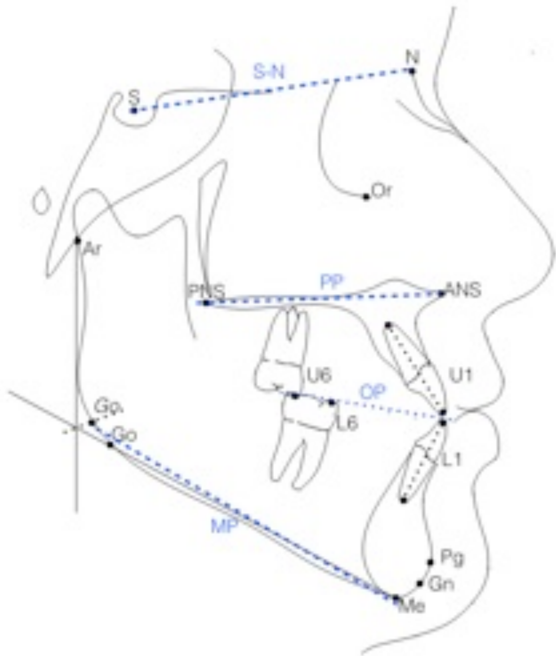


FIGURE 1. Cephalometric Landmarks Identified on Pre-Intervention Lateral Cephalograms

Vertical and angular measurements were generated for the following:

- Vertical:
    - Posterior Facial Height (PFH) to Anterior Facial Height (AFH):
        - S to Go: N to Me
    - Upper Facial Height (UFH) to Lower Facial Height (LFH):
        - N to PP: PP to Me
    - Mandibular Plane Angle (MPA):
        - SN to *Go*Me
    - Palatal Plane Angle:
        - Sn-PP
    - Gonial Angle:
        - Ar-Go to Go-Gn

- Dental:
    - Upper Incisor Position:
        - U1-NA (mm and degrees)
    - Lower Incisor Position:
        - L1- NB (mm and degrees)
    - Lower Incisor to Mandibular Plane (IMPA):
        - (L1 to Go-Gn)
    - AOB measured perpendicular to OP
    - OJ (measured with OP)
- AP:
    - Maxilla to Cranial Base:
        - SNA
    - Mandible to Cranial Base:
        - SNB
    - Maxilla to Mandible:
        - ANB

A standard millimetric ruler included in the forehead positioner of the cephalograms was used to calibrate millimetric measurements. When a ruler was absent and a mid-sagittal forehead positioner was present, the specifications of the positioner were obtained from the manufacturer and the known width of the device was used as a surrogate ruler (number=5). When both ruler and forehead positioner were absent, a ruler was generated using an estimate of the mesiodistal width of the mandibular first molar (number=15). To determine an appropriate molar width estimate, 20 casts were chosen at random from patient files at the University of Washington Orthodontic clinic and the mandibular first molars were measured on the pre-treatment casts with digital calipers. An average molar width was calculated from these measurements to be 11.5 mm, which was determined to be a reasonable estimate across different ages, sexes and ethnicities based on similar averages reported in the odontometric literature for mandibular molar widths in American populations [35,36]. To ensure that these estimated values did not skew our statistical analysis, a sensitivity analysis was performed excluding the estimated sample and the sample data was retained when no difference was found.

In total 12 patients were eliminated from the study based on their lateral cephalograms. Five of these patients revealed positive overbite of all incisors in both their intraoral photograph and lateral cephalogram and thus did not qualify for the study based on our definition of AOB. Another 7 cephalograms were eliminated on the basis that they were non-diagnostic either due to very poor quality images or inadequate information in the field of view. One patient was eliminated prior to analysis due to patient age (under 18 years old).

Several cephalograms also contained errors that needed to be adjusted for. Some cephalograms were missing information. For example, 5 images cropped off some portion of the bony chin. For 4 of these images, enough data was present to extrapolate the position of menton and gnathion and all measurements were retained. For 1 image, too much information was missing so that all measurements using menton and gnathion were disregarded (MPA, AFH:PFH, UFH:LFH), but the remaining angular and millimetric measurements were retained. In 2 of the cephalograms, the patient was captured when not fully biting down into MIC. For these images, all measurements were retained with the understanding that angular and millimetric measurements would be slightly exaggerated. Finally, 2 images revealed patients with prior orthognathic surgery. All data points for these patients were included despite surgical alterations in the patient's native skeletal parameters (e.g. MPA changes), since a history of prior surgery was not considered to be a criterion for exclusion.

Data Analysis

Statistical analyses were performed to examine how dentofacial, patient, and practitioner characteristics influence treatment recommendations suggested by the orthodontists. All analyses were performed using SAS software (SAS v9.4, SAS Institute Inc., Cary NC). The association of each of the dentofacial, patient, and practitioner characteristics specified below with different treatment recommendations were ascertained using a Chi-square test for categorical variables. For patient cephalometric variables (including OB, SN-MP, ANB), ANOVA was also performed. Dentofacial characteristics included: profile, molar classification, maxillary crowding, mandibular crowding, posterior cross-bite, and facial pattern. Patient characteristics included: age, sex, race/ethnicity, insurance, education, and treatment goals. Practitioner characteristics included: age, sex, race/ethnicity, training institution, and year received orthodontic training. Treatment options were limited to 4 main groups: fixed appliances (with or without extractions), Temporary Anchorage Devices ((TADs); with or without extractions), Aligners (without extractions), and surgery (with or without extractions). Before determining treatment groups, we first wanted to ensure that extraction and non-extraction patients were not significantly different in terms of their dentofacial characteristics (OB, SN-MP, ANB, molar classification, crowding). We also looked at whether there was a difference in patient acceptance rate between extraction and non-extraction plans. Other than degree of crowding, extraction and non-extraction patients were similar across dentofacial characteristics, including severity of overbite, mandibular plane and AP discrepancy. Patients also accepted extraction and non-extraction plans at approximately the same rate. It was therefore determined not to separate extractions out as a separate treatment group so that robust sample sizes could be maintained.

For the dentofacial domain, logistic regression analysis was carried out for the dichotomous outcome of surgery most recommended treatment plan vs. no surgery. Cephalometric values were separated into quartiles and molar classification and crowding were entered dichotomously. Variables were examined with frequency tables [2x4 contingency tables] to ascertain if there was a dose-response/linear trend relationship. Associations with $p<0.2$ were entered in the model and retained if $p<0.1$. The final logistic regression model began with those significantly associated characteristics ($p<0.1$) and were retained in the overall model if a significance level of $p<0.05$ was returned. This final model then explains independent associations for dentofacial characteristics relating to the treatment recommendation of surgery vs. no surgery.

Chapter 3. RESULTS

A total of 212 adult patients were initially enrolled in the present investigation, 199 (93.4%) of which participated until the end of the study. Patients were dropped after enrollment because it was determined they did not qualify for inclusion based on age (1 patient under 18) and lack of anterior open bite (5 patients with positive vertical overlap of all incisors). An additional 7 patients had to be dropped from the study because the pre-intervention cephalogram was not of diagnostic quality. No practitioners lost all patients because of these exclusions and no practitioners were dropped from the survey data.

Mean age of the AOB patients was 32 years, with patient ages ranging from 18 to 68 years old. Sex distribution for the included patient population was 26% male and 74% female, which corresponds to the national trend of more females than males among US adult orthodontic patients [37]. The patient race distribution was 56% Caucasian, 25% Hispanic, 9 % Black, 7 % Asian and 3 % Multi-race. Patients were well-distributed across different education levels; 21% had a high school diploma or less, 31% attended some college or possessed an associate degree, 33% had a bachelor degree and 15% had a graduate degree. A high percentage of the surveyed patients had some dental insurance (73%). Of those with insurance, 54% had orthodontic coverage. Most patients did not know whether their dental insurance would cover jaw surgery (63%)(Table 3).

TABLE 3. Patient Demographics

	Number (%)
Age	
18-24 years25-34 years	62 (32%)
35 years +	78 (40%)
	55 (28%)
Sex	
Male	51 (26%)
Female	145 (74%)
Race	
White	109 (56%)
Black	17 (9%)
Asian	14 (7%)
Multi-Race	6 (3%)
Hispanic	49 (25%)
Previous Orthodontics	
Yes	63 (32%)
No	126 (65%)
Don't Know	6 (3%)
Dental Insurance	
None	41 (21%)
Private	120 (61%)
Public/Government (only)	15 (8%)
Other	8 (4%)
Don't Know	12 (6%)
Dental Insurance Covers Orthodontics	
Yes	93 (54%)
No	63 (36%)
Don't know	17 (10%)
Dental Insurance Covers Jaw Surgery	
Yes	23 (14%)
No	39 (23%)
Don't know	107 (63%)
Highest Level of Education	
High School Graduate or Less	40 (21%)
Some College or Associate Degree	60 (31%)
Bachelors Degree	65 (33%)
Graduate Degree	30 (15%)

A total of 68 practitioners submitted patients for this study however, survey data was incomplete for 4 of the practitioners. The sex distribution of practitioners was 68% male and 32% female. Most practitioners were orthodontists (n=65, 96%), with a total of 3 general practitioners (4%) contributing cases. Participating practitioners were well distributed across different age groups and experience levels (Table 2). The majority were from private practice settings; either as a solo practitioner (n=37, 55%), owner of a non-solo practice (n=16, 24%), or as an associate (n=7, 10%). The remaining participants were from academic, federal or managed care settings (n=7, 10%). Participating practices were located across the US, with the majority from the Western and Southwestern regions, followed by Northeastern, South Atlantic, South Central and Midwestern regions respectively (Table 1).

PRACTITIONER DEMOGRAPHICS

Practitioners reported their utilization frequency for various AOB treatment approaches on the practitioner enrollment form (Table 4). When asked whether they typically used fixed appliances and/or clear aligners, only 1% of practitioners reported never using fixed appliances for the treatment of anterior open-bite, while the vast majority (93%) of practitioners reported using fixed appliances often. Use of aligners was more variable among the participating practitioners. Nearly one quarter of the practitioners report never using aligners for open bite correction (22%), while 40% of practitioners reported using aligners often, and 38% said they use aligners occasionally for open bite treatment.

In addition to the main appliance type, practitioners were queried how often they used any of three main treatment strategies for AOB, namely extractions, surgery and TADs. Most practitioners reported using extractions occasionally to manage AOB (68% upper arch extractions, 67% lower arch extractions). More practitioners reported using upper arch extractions often than using lower arch extractions often (25 % vs. 9 % respectively) and less than 10% of providers report never using extractions for AOB correction. Most practitioners also reported occasional surgical treatment for AOB (79% maxillary jaw surgery, 76% mandibular surgery), while few reported employing surgical means often (15% maxillary, 10% mandibular) or not at all (6% maxillary, 13% mandibular). Among the surveyed doctors, use of TAD mini-plates was very low, with 76% reporting that they never use them. TAD mini-screws were used more frequently however, with 63% of practitioners reporting occasional use and 10% reporting that they often use mini-screws for open-bite correction (Table 4).

Also of interest, half of the practitioners reported never using adjunctive speech therapy by a speech language pathologist (48%), and almost all practitioners reported never using tongue exercises prescribed by the dental professional (96%). Use of tongue cribs and appliances was much higher however, with 54% of practitioners reporting that they use these appliances occasionally and 22% reporting that they use them often. Accelerated orthodontic techniques, such as corticotomy and vibration, were unpopular among the surveyed doctors, with 77% never using corticotomy and 70% never using vibration techniques (Table 4).

TABLE 4. Practitioner Reported Frequency of Treatment Strategy for Adult AOB Patients

	Not at all		Occasionally		Often	
	N	%	N	%	N	%
Treatments						
Fixed appliances	1	1%	4	6%	63	93%
Clear Aligners	15	22%	26	38%	27	40%
Maxillary arch extraction	5	7%	46	68%	17	25%
Mandibular arch extraction	6	9%	45	66%	6	9%
TAD Mini-screws	18	26%	42	62%	7	10%
TAD Mini-plates	51	75%	15	22%	1	1%
Maxillary Jaw Surgery	4	6%	54	79%	10	15%
Mandibular Jaw Surgery	9	13%	52	76%	7	10%
Tongue or thumb crib	16	24%	37	54%	15	22%
Speech therapy	32	47%	26	38%	10	15%
Occlusal equilibrium	19	28%	37	54%	11	16%
Elastics	0	0%	8	12%	60	88%
Interproximal reduction	3	4%	37	54%	27	40%
Maxillary Expansion	2	3%	40	59%	26	38%
Headgear	35	51%	25	37%	7	10%
Corticotomy	50	74%	15	22%	0	0%
Vibration	47	69%	17	25%	3	4%
Tongue Exercises	65	96%	0	0%	3	4%
Splint/BiteBlock	64	94%	2	3%	2	3%
Other treatment	64	94%	3	4%	1	1%

When we looked at the difference in treatment planning trends between general practitioners (GPs) and orthodontists, there was no statistical difference detected between the groups. While it would certainly be expected that specialists are more comfortable prescribing more complex and invasive treatment options, such as surgery, TADs and extractions, the number of GPs surveyed was small and therefore differences could not be detected at a significant level. However, in this particular sample, this did appear to be the case as no GPs often recommended any of these methods, while a fair number of orthodontists often prescribed TADs (11%), surgery (15%) and extractions (26%).

Table 5. AOB Treatment Planning Frequency by Practitioner Characteristics

	Extract Often		TAD Often		Surgery Often	
	N	%	N	%	N	%
Specialty						
Orthodontist	17	26%	7	11%	10	15%
General practitioner	0	0%	0	0%	0	0%
	p=0.4		p=0.6		p=0.6	
Country attended dental school						
United States	12	21%	3	5%	7	12%
Other	5	45%	4	36%	3	27%
	p=0.09		**p=0.002**		p=0.2	
Demographics						
Gender						
Male	13	28%	5	11%	7	15%
Female	4	18%	2	9%	3	14%
	p=0.4		p=0.8		p=.9	
Age						
< 45 years	9	36%	2	8%	3	12%
45 - 54 years	4	19%	4	19%	1	5%
55 and older	4	18%	1	5%	6	27%
	p=0.3		p=0.3		p=0.1	
Race						
White/Caucasian	7	18%	2	5%	6	15%
Asian	7	41%	4	24%	3	18%
Multi-race	1	50%	1	50%	0	0%
Hispanic	2	25%	0	0%	0	0%
	p=0.2		**p=0.03**		p=0.6	
Practice experience						
Years since graduated dental						
<10 yrs since grad	3	43%	1	14%	0	0%
10-19 yrs since grad	7	28%	1	4%	3	12%
20-29 yrs since grad	4	21%	4	21%	4	21%
30+ yrs since grad	3	19%	1	6%	3	19%
	p=0.6		p=0.3		p=0.5	

When we examined how practice experience affected treatment planning trends, we found no difference in the percentage of practitioners prescribing surgical plans based on their years of practice. In this sample however, no practitioners prescribed surgery often in the 10 years since graduation group; while between 12-21% of the more experienced groups reported often prescribing surgery. Though this may seem to suggest inexperienced practitioners are more hesitant to prescribe surgery for their AOB patients, the difference between groups was not statistically significant (p=0.5). We also did not detect a difference in the likelihood of a practitioner treatment planning extractions based on their level of experience. The percentage of practitioners that reported they often prescribe extraction treatment did decrease with practice experience from 43% in the less than 10 years since graduation group down to 19% in the 30 or more years since graduation group. However, this difference again was not statistically significant (p=0.6).

Among the practitioners, there was no significant difference between groups often prescribing TADs, surgery, or extractions on the basis of their age or gender. There was a difference between groups however, based on where a practitioner attended dental school. Compared to those who attended school in the U.S., more foreign trained doctors prescribe TAD treatment often (36% foreign trained recommend TADs often vs. 5% U.S. trained, p=0.002). There was also a difference noted between groups based on practitioner race. Only 5% of Caucasian providers and 0% of Hispanic providers often prescribe TADs, while 24% of Asian practitioners reported that they often prescribe TADs for open-bite correction (p=0.03).There was no significant difference between groups that often prescribe surgery or extractions based on race.

While practice location and region did not seem to be associated with frequency of treatment recommendations, practice type seemed to play a role in how often practitioners suggest certain treatment plans (Table 6). A higher percentage of practitioners in a federal government, academic, or managed care setting prescribed extractions often (57%) than those practitioners that own a solo or group private practice (16% and 13% respectively, p=0.01). The same trend is observed for TADs, with 57% of the government, academic and managed care providers responding that they often prescribe TADs and 5-6% of private practice owners reporting the same. Interestingly, the group of associates in private practice responded most similarly to government, academic and managed care providers for extractions (both had 57% often performing extractions) and most dissimilarly for TADs (0% of associates often prescribe TADs compared to 57% of federal government, academic or managed care providers).

TABLE 6. AOB Treatment Planning Frequency by Practice Characteristics

	Extract Often		TAD Often		Surgery Often	
	N	**%**	**N**	**%**	**N**	**%**
Practice type						
Solo, private practice	6	16%	2	5%	4	11%
Owner, non-solo, private practice	2	13%	1	6%	1	6%
Associate/employee private practice	4	57%	0	0%	1	14%
Federal govt, Academic, Other managed care	4	57%	4	57%	3	43%
	p=0.01		**p=.0004**		**p=0.1**	
Urbanicity of primary practice location						
Inner City of Urban Area	4	31%	3	23%	2	15%
Urban (not inner city)	5	21%	2	8%	3	13%
Suburban	7	32%	1	5%	4	18%
Rural	1	14%	0	0%	0	0%
	p=0.7		p=0.2		p=0.7	
Region						
Western	4	13%	3	10%	5	17%
Midwest	0	0%	0	0%	0	0%
Southwest	6	43%	3	21%	2	14%
South Central	2	40%	0	0%	2	40%
South Atlantic	2	33%	1	17%	1	17%
Northeast	3	27%	0	0%	0	0%
	p=0.3		p=0.5		p=0.4	

PATIENT DEMOGRAPHICS

Patient treatment plan acceptance was reported by practitioners in the enrollment questionnaires. The acceptance rate of the most recommended treatment plan was highest for aligners. According to practitioner reporting, 100% of patients accepted this plan when it was most recommended. Fixed appliances without surgery or TADs were almost as well accepted by patients, with 91.4% accepting this plan. Patient acceptance rate of surgery dropped down to 60.6% when it was the most recommended treatment plan. Acceptance rate for TADs was only slightly better, with 64.7% accepting a TAD treatment plan when most recommended. When all plans were split dichotomously based on whether extractions were included, there was little difference between acceptance rates. In this population, slightly more patients accepted an extraction plan (79.2%) than accepted a non-extraction plan (77.3%) when it was most recommended. When a treatment plan was rejected, the main reasons for doing so according to the practitioner, were that the patient deemed it too costly (40%), too risky (58%) or did not want surgery (58%). Practitioners reported that very few patients rejected treatment plans because they did not want extractions (5%) and none rejected a plan because it would be "too long". When the patients were asked the same question, the percentages were mostly consistent with the practitioner reports. However, a higher percentage of patients said they rejected the most recommended plan because it involved extractions (14% patient report vs. 5 % practitioner report), and slightly lower percent rejected treatment for being too risky (36% vs. 58%) or involving surgery (55% vs 58%). The percent of patients rejecting treatment as being too costly was similar according to patient and practitioner report (41 vs. 40% respectively).

Treatment plans were stratified into "invasive" vs. "non-invasive" groups, namely extraction vs. non-extraction and surgical vs. non-surgical, to see whether invasiveness of the treatment plans confounded associations between patient demographic characteristics and treatment plan acceptance (Table 7,8). There was no association between a patient's education level and their acceptance rate of the most recommended treatment plan when the treatment plans were separated out into these categories (Table 7,8). There was also no association between a patient's age and their likelihood of accepting the most recommended treatment plan when the treatment plans were divided by recommendation for extraction and recommendation for surgery (Table 7,8). There was an association however, between patient insurance coverage and their acceptance of the most recommended treatment plan when that plan was surgical (Table 8). When a patient did not have medical insurance that covered surgical costs, the acceptance rate for a surgical plan was much lower than when they did have insurance coverage of the procedure (47.7% vs. 78.6% respectively, p=0.009). This was not unexpected, as the cost of surgery is very high and may be prohibitive to some patients.

TABLE 7. Association of Patient Demographic Characteristics and Acceptance of Most Recommended Treatment Plan, stratified by Extraction vs. Non extraction

Age				Education				Medical Insurance Covers Jaw Surgery			
		Accept				Accept				Accept	
Treatment	**N**	**N**	**%**	**Treatment**	**N**	**N**	**%**	**Treatment**	**N**	**N**	**%**
No extractions				**No extractions**				**No extractions**			
Age 18-24	37	27	73.0%	***Education <BS***	72	57	79.2%	***No***	114	86	75.4%
Age 25+	103	81	78.6%	***Education BS +***	68	52	76.5%	***Yes***	27	23	85.2%
	p=.5				p=.7				p=.3		
Extractions				**Extractions**				**Extractions**			
Age 18-24	25	20	80.0%	***Education <BS***	21	16	76.2%	***No***	41	32	78.0%
Age 25+	28	22	78.6%	***Education BS +***	32	26	81.2%	***Yes***	12	10	83.3%
	p=.9				p=.6				p=.7		

TABLE 8. Association of Patient Demographic Characteristics and Acceptance of Most Recommended Treatment Plan, stratified by Surgery vs. Non Surgery

Age				Education				Medical Insurance Covers Jaw Surgery			
		Accept				Accept				Accept	
Treatment	N	N	%	Treatment	N	N	%	Treatment	N	N	%
No surgery				No surgery				No surgery			
Age 18-24	31	28	90.3%	*Education <BS*	61	54	88.5%	*No*	111	97	87.4%
Age 25+	90	79	87.8%	*Education BS +*	60	54	90.0%	*Yes*	11	11	100.0%
	p=.7				p=.9				p=.2		
Surgery				Surgery				Surgery			
Age 18-24	31	19	61.3%	*Education <BS*	32	19	59.4%	*No*	44	21	47.7%
Age 25+	41	24	58.5%	*Education BS +*	40	24	60.0%	*Yes*	28	22	78.6%
	p=.8				P=.9				**p=.009**		

PATIENT DENTOFACIAL CHARACTERISTICS

Patient dentofacial characteristics were examined for associations with practitioner treatment planning recommendations. Dentofacial characteristics included mandibular plane angle (SN-MP), skeletal AP discrepancy (ANB), molar AP classification, degree of open-bite (OB) and presence of crowding. There was an overall mean difference between groups based on overbite (p=0.0122, Table 9). The mean anterior-openbite was about 1 mm more severe on average in those patients who were recommended surgery as the primary treatment option compared to the other treatment groups (Table 9). The population characteristics for each treatment group can be seen in Figure 2.

When mean overbite (mm) values were compared between those patients recommended surgery as the first treatment option and those patients not recommended surgery (i.e all other treatment groups), this difference persisted at a clinically and statistically significant level (Mean OB Non surgery = -2.18, Mean OB Surgery =-3.2, p= 0.0012, Figure 3). However, when treatment groups were compared individually to one another (e.g. surgery mean different than aligner mean) and the sample was adjusted for clustering (multiple patients from the same practitioners), the statistical significance for the difference in mean OB disappeared (Table 10, p =0.38).

TABLE 9. ANOVA (unadjusted) for Dentofacial Variables : Overbite, SN-MP, ANB

Treatment	N	Mean OB (mm)	*St dev*	Mean SN-MP (°)	*St dev*	Mean ANB (°)	*St dev*
Fixed Appliance	**81**	**-2.11**	**1.85**	**32.53**	**1.01**	**3.57**	**2.61**
TADs	**17**	**-2.21**	**2.05**	**32.08**	**2.23**	**2.88**	**2.62**
Surgery	**71**	**-3.21**	**2.47**	**37.04**	**1.05**	**3.16**	**3.69**
Aligners	**20**	**-2.38**	**1.59**	**34.68**	**2.75**	**4.03**	**2.61**
p		***0.012***		***0.0002***		***0.565***	

TABLE 10. ANOVA Adjusted for Clustering for Dentofacial Variables : Overbite, SN-MP, ANB

Treatment	N	Last Squares Mean OB (mm)	*SE*	Least Squares Mean SN-MP (°)	*SE*	Least Squares Mean ANB (°)	*SE*
Fixed Appliance	**81**	**-1.98**	**0.32**	**32.65**	**1.01**	**4.02**	**0.47**
TADs	**17**	**-2.44**	**0.70**	**31.54**	**2.23**	**2.48**	**1.04**
Surgery	**71**	**-2.81**	**0.33**	**36.49**	**1.05**	**3.10**	**0.49**
Aligners	**20**	**-2.60**	**0.86**	**33.75**	**2.75**	**2.74**	**1.28**
p		***0.38***		***0.048***		***0.37***	

Figure 2. Distribution of OB (mm) Among Most-Recommended Treatment Groups

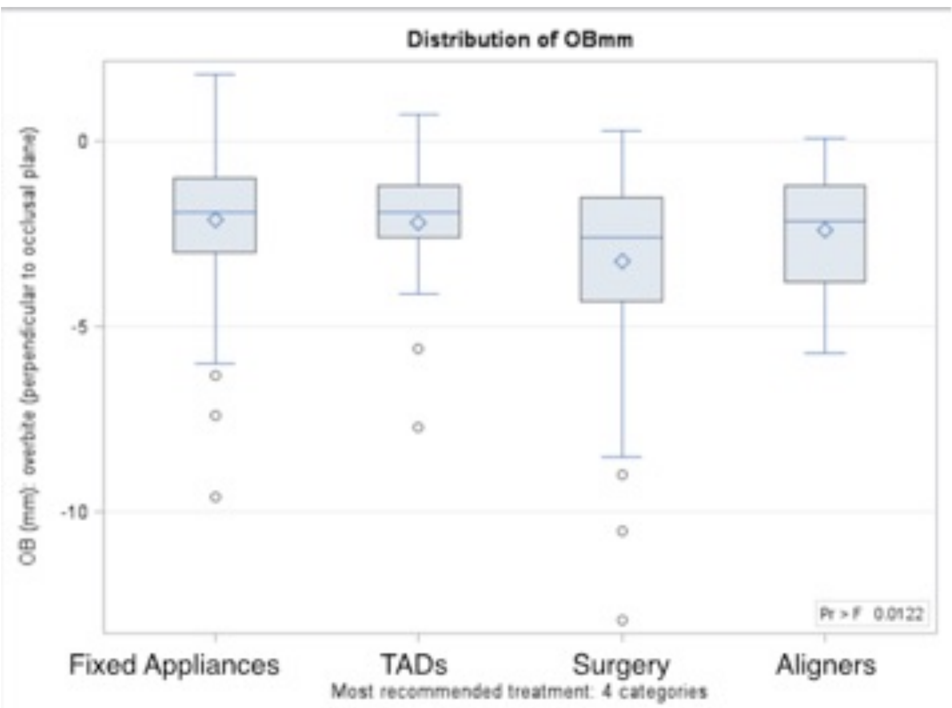
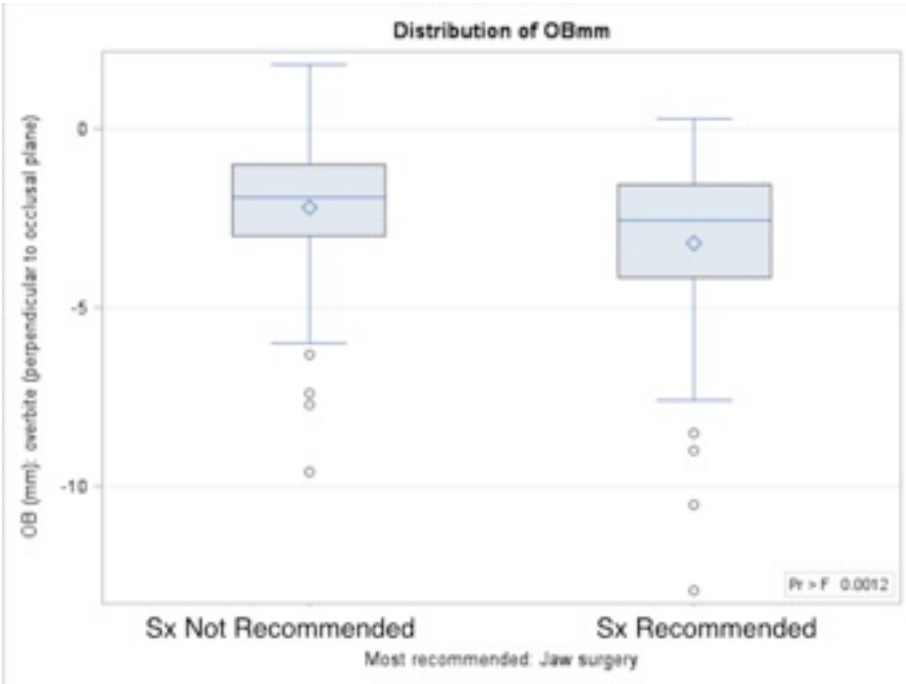


Figure 3. Mean Overbite (mm) in Surgery-Most Recommended vs Surgery Not Recommended



In addition to degree of AOB, the mandibular plane (Sn-MP) also tended to be steepest in the patient group recommended surgery versus those who were recommended TADs, aligners or fixed appliances. There was a statistically significant overall difference between groups based on mean Sn-MP (Pr>F= 0.0002, Table 9). The distribution of Sn-MP among the recommended treatment groups can be seen in figure 4. Mean mandibular plane angle was also compared in patients who were most recommended surgery vs. those who were not recommended surgery first (Figure 5). When analyzed this way, there was a difference of 4 degrees between the mean mandibular plane angle of surgical vs. non-surgical patients, which can be considered clinically significant (Sn-MP surgery = 36.94, Sn-MP non-surgery = 32.84, Pr>F= >0.0001). When the means were compared between surgery and each of the other three treatment categories, the statistically significant difference in means persisted when surgery was compared to TAD and Fixed appliance patients (p=0.045 and p=0.01 respectively) but disappeared when compared to aligner patients (Table 10).

Figure 4. Distribution of SN-MP (°) Among Most-Recommended Treatment Groups

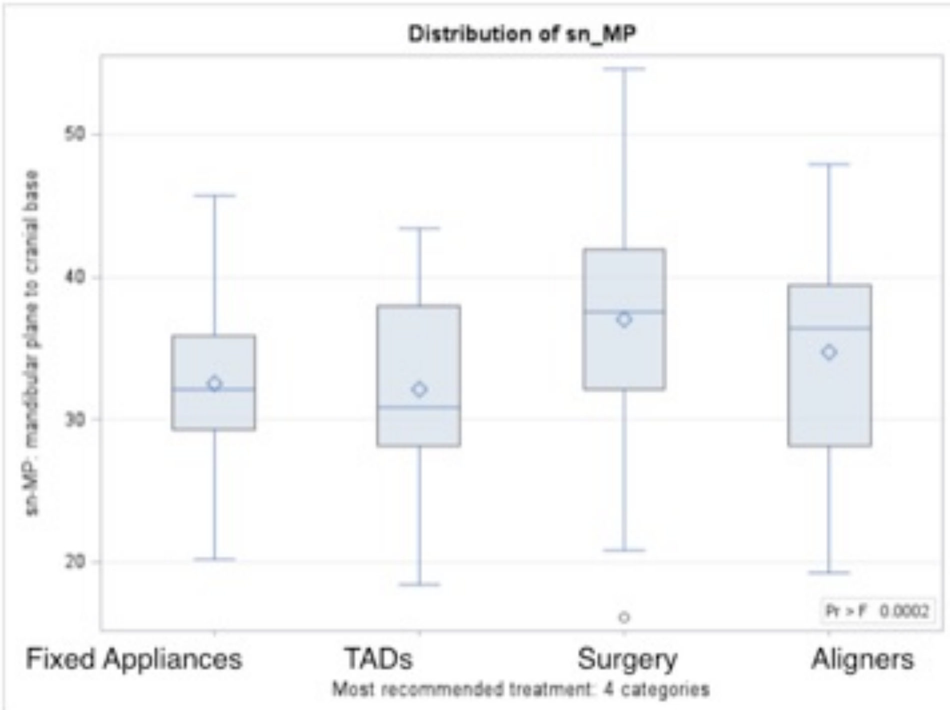
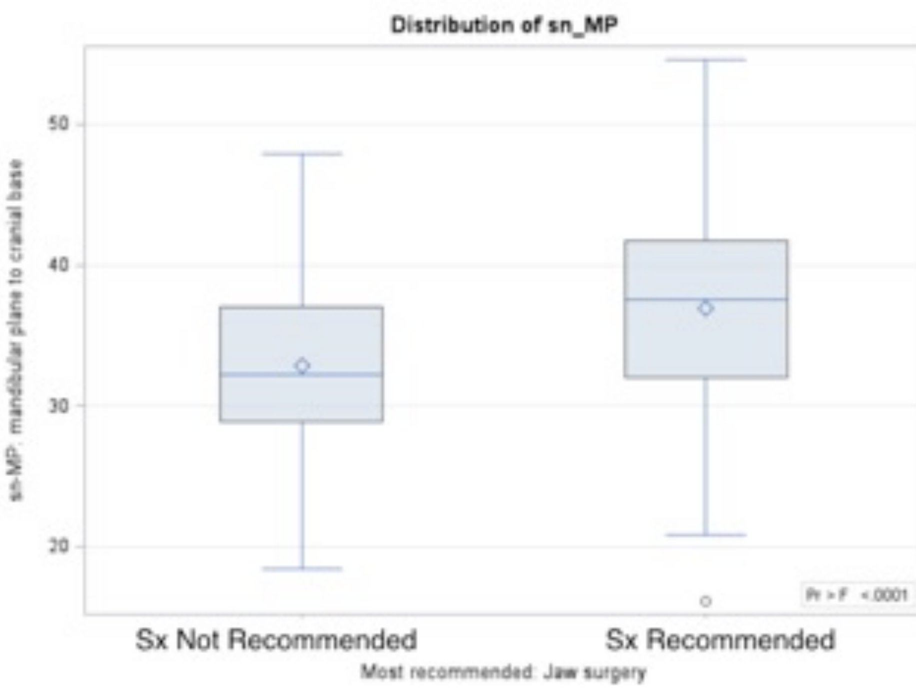
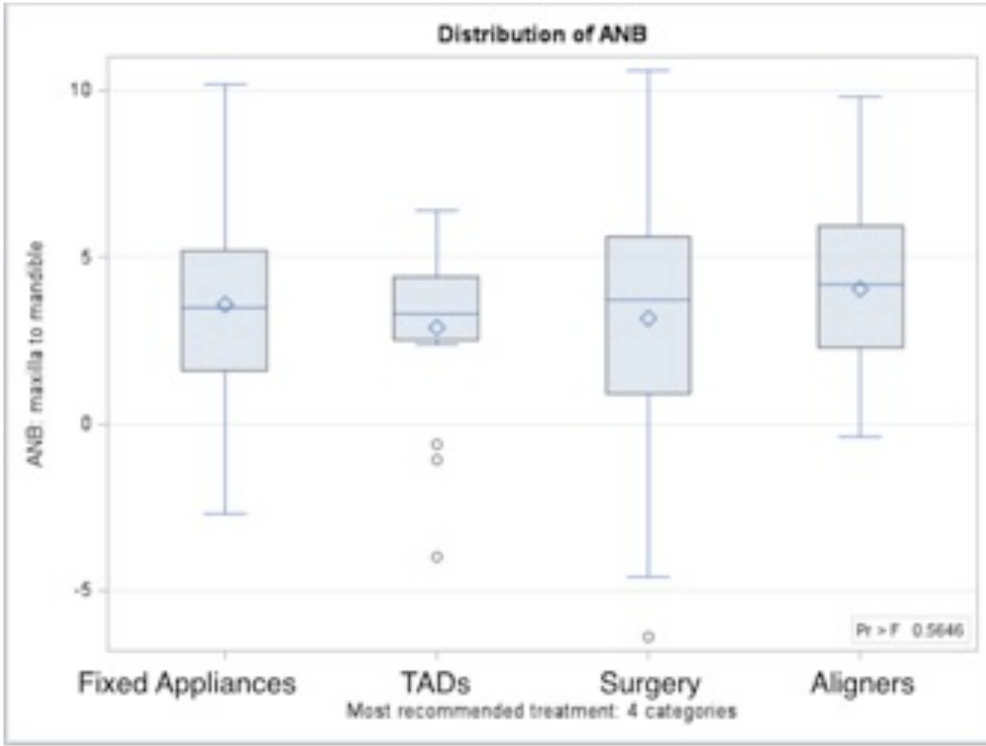


Figure 5. Mean Mandibular Plane Angle (°) in Surgery-Most Recommended vs. Surgery Not Most Recommended Patient Groups



The distribution of ANB was similar among treatment groups and the mean ANB was not significantly different across the recommended treatment groups (Table 9, figure 6).

Figure 6. Distribution of ANB (°) Among Most-Recommended Treatment Groups



In general, univariate analysis revealed that certain characteristics tend to be worse on average in the surgery group compared to the other treatment groups (e.g. mn plane and OB). A logistic regression analysis was also performed, which confirmed that there are multiple dentofacial variables associated with increased odds of prescribing surgery as a primary treatment recommendation. For the analysis, SN-MP and OB data were divided into quartiles and molar Class II and crowding were recorded dichotomously. According to the logistic regression model, practitioners were almost 3 times as likely to recommend surgery when the patient had a Class II molar relationship. The practitioner was also 1.5 times more likely to recommend surgery as one moves to increasingly steeper mandibular plane quartiles and is about

25% less likely to recommend surgery as overbite improves across quartiles (Table 11).

TABLE 11. Logistic Regression Model for Recommendation of Surgery vs. Non-Surgery Across Dentofacial Characteristics

	Crude			Reduced model		
Characteristic	**OR**	**P**		**OR**	**95% CI**	**P**
CEPH (quartiles)						
Sn-MP	1.77	<.001		**1.53**	1.12-2.10	**.01**
OB(mm)	0.67	.003		**0.72**	0.56-0.94	**.03**
ANB	1.02	.9		x		
Molar Class II	3.64	<.001		**2.78**	1.44-5.37	**.004**
Crowding - either Mx/Mn	1.56	.14		x		

Chapter 4. DISCUSSION

In this study, we examined the ways in which practitioner and patient demographic characteristics and patient dentofacial characteristics relate to current treatment planning trends in adult AOB cases in the United States. The current literature indicates that the severity of open-bite among non-growing adults assigned to surgical vs non-surgical treatment groups has been surprisingly similar in study populations[21]. Obviously, parameters other than the degree of initial overbite play a role in the decision-making process about whether to relegate a patient to an invasive option like surgery or a less invasive option, such as aligners. These factors have not been elucidated by past studies, so we attempt here to determine some of the patient and practitioner characteristics that influence how treatment decisions are currently being made for adult AOB.

Practitioner demographic characteristics were explored relative to the frequency with which providers prescribed general treatment strategies for their AOB patients. Practitioners did not differ significantly as a group from one another in treatment planning trends based on their age, gender, or location. However, more practitioners who received their dental training outside of the US reported that they prescribed TAD treatment often for AOB than those trained in the US (36% vs 5% respectively, p=0.002). This corresponds to findings from a 2008 poll of American Association of Orthodontists (AAO) members that found that orthodontists practicing outside the US placed significantly more miniscrews than their U.S. counterparts [38]. In addition, we found that more practitioners of Asian (24%) descent reported that they often prescribe TADs for AOB treatment (compared to 5% Caucasian, p=0.03). Miniscrew implants have historically been very popular in Asian countries, where several mini implant systems were developed. It is therefore unsurprising that a higher percentage of foreign trained practitioners, particularly those of Asian heritage, would prescribe TAD treatment for AOB often. We initially also suspected that newer practitioners would be more likely to prescribe TADs often, but this was not borne out in the results. As of the 2008 AAO member survey, of the 555 practicing orthodontists surveyed, 91.6% had received no training in miniscrew placement during their orthodontics residency. Conversely, most residency programs now train their students on the placement and utilization of miniscrews. Contrary to what we had suspected, more practitioners who graduated between 20-29 years ago reported often using TADs for AOB than did those in the most recent graduation group. The differences observed between the experience groups however, were not statistically significant. The lack of statistical significance may be due to a small group of respondents citing frequent TAD usage and a consequent lack of power rather than a true lack of difference between the two populations. Alternatively, although practitioners who graduated many years ago likely would not have received in-school instruction for miniscrews, they may have sought out continuing education courses on this subject, thus negating the differences in comfort level based on training. It is also possible that new practitioners are employed by corporations or private practices where they are not given full autonomy to prescribe this treatment option.

For the most part, patient demographic characteristics were not associated with the likelihood of their accepting a specific treatment option. One might suspect that education level might have an association with a patient's willingness to accept riskier, more invasive treatment options such as surgery or extractions. It may be that the more educated patients might more readily appreciate the complexities and future benefits of invasive treatment options and be more likely to accept them, despite their disadvantages. Conversely, highly educated individuals might also better understand the attendant risks of surgery and extractions and reject those treatment options more often due to their potential adverse effects. In our sample, there was no apparent association either way with a patient's level of education and their willingness to accept either extraction treatment or surgical treatment. Although we initially suspected that younger patients might be more willing to pursue a surgical option, there was also no association with a patient's age and their acceptance of the specific treatment options of surgery or extractions. The only patient factor that was significantly associated with acceptance of the most recommended treatment plan was whether a patient had medical/dental insurance to cover the procedure when surgery was recommended. When a patient had insurance coverage, they accepted surgery 78.6% of the time and when they did not, the acceptance rate dropped to below 50% (47.7 %, p=0.009). Patient acceptance of treatment plans may be too complex and too unique to the individual to be detected easily with univariate analyses. Further multivariate analysis could be performed, including additional factors that were not examined here, such as history of previous orthodontics, chief complaint, location (region and urbanicity), habits, etc. to determine whether any associations can be detected in a more complex models.

There were several patient dentofacial characteristics that appeared to be different, on average, across each of the four main recommended treatment strategies. After determining that patient characteristics and patient acceptance rate of treatment was no different between extraction and non-extraction groups (with the obvious exception of crowding), it was decided not separate extraction cases from the four main treatment groups. The four categories of treatment were then: Aligners, TADs, Fixed Appliances and Surgery. On average, both mean mandibular plane angle and degree of AOB (measured in mm overbite) tended to be more severe in those patients that were recommended surgery (Table 9). When all other treatment groups were lumped into a "non-surgical" category, the mean difference in overbite between surgery and non-surgery patients was about 1 mm and the mean mandibular plane angle difference was about 4 degrees (Figures 3,5). These differences were statistically significant and are also clinically significant.

While it was not surprising that the most skeletally and dentally severe patients were treated with surgery; it was surprising that the TAD treatment group did not appear to differ from either the aligner or fixed appliance groups based on these characteristics. According to multiple authors, moderate to severe open-bites can be treated just as effectively with either surgery or TAD facilitated posterior molar intrusion [25, 27-29]. Deguchi and colleagues reported that with modern TAD-facilitated techniques, molar intrusion can accomplish many of the same benefits of surgical open-bite correction including increased overbite and reduced total facial height, while having the added benefit of being much less invasive. Moreover, TAD overbite correction can be achieved mainly via posterior intrusion rather than extrusion of the incisors, which is an undesirable side effect frequently seen in surgically corrected AOB patients [25]. Of course, stability of correction with TADs, as with all methods of correction, needs additional studies [39].

The degree of AP skeletal discrepancy, measured via the surrogate cephalometric measurement, ANB, was no different between treatment groups. One might assume that skeletally prognathic or retrognathic patients would be more likely to be surgical cases, since it is difficult for the orthodontist to tackle severe problems in multiple planes of space without repositioning the aberrant skeletal units. However, no mean difference in ANB between treatment groups was noted. One reason that ANB might have not been different on average is that the high and the low values, i.e. the severe cases, might add together to cancel one another out in the surgery group. If there were many severely low ANB and high ANB cases in the surgical group, the overall mean could still have been similar to other treatment groups even though the patient population was more skeletally atypical. This may very well have been the case since the surgical group shows the largest spread in ANB data (Figure 6) and there was a larger standard deviation for ANB in this treatment group (Table 9). Furthermore, when we looked at patient AP discrepancy dentally rather than skeletally, we noted an odds ratio of 2.78 for surgery when Class II molars were present–practitioners were nearly 3 times more likely to advocate surgery when the patient had an AOB and was dentally Class II. Although dental and skeletal AP discrepancies don't always perfectly coincide, this seems to indicate that open-bite individuals with antero-posterior discrepancies are more likely to have surgery recommended. This is particularly true for those with increased overjet.

There were several limitations to our study. For one, the severity of the overbite therefore was likely underestimated in some patients based on our cephalometric technique of recording anterior open-bite. Note in Figure 2 that the range for overbite includes some patients with positive overlap of their incisors. This is a consequence of the fact that our definition only required *at least* one incisor to have zero or negative vertical overlap with the opposing incisor.

The central incisor may or may not have been the tooth that qualified the patient as open-bite, but this was the only tooth that was traced and it may have had positive overlap but no contact.

Another limitation of our study is that subjects came from different practices across the country and consequently, their pre-intervention cephalograms were taken on a number of different machines, both film and digital. While every effort was made to obtain the highest quality images possible, there were several images that were of poor quality or were excessively cropped so that craniofacial structures such as the anterior cranial base or the patient's chin were missing from the image. In order to trace the images as accurately as possible, poor quality images were first adjusted using the various editing tools in the Dolphin Digital Imaging Software (version 11.0; Dolphin Imaging and Management Solutions, Chatsworth, Calif). Images were also traced at increased magnification to ensure that the proper structures could be adequately visualized. Additionally, whenever there was any difficulty establishing a point location, consensus agreement between the two tracers helped to ensure that structures were identified as consistently and accurately as possible. Even with every effort to adjust and magnify images however, there were 3 subjects that had to be eliminated from the study due to non-diagnostic image quality. An additional 4 patients had to be dropped because examiners were unable to retrieve enough information from the overly cropped images to accurately trace the pre-intervention cephalogram. Although it is unlikely that dropping these subjects lead to any bias in the sample, their loss did detract from the overall sample size.

Several cephalograms that did not include a ruler in the image. One accepted method for creating a millimetric reference in images that lack rulers is to use the image DPI (dots per inch) resolution. Unfortunately, most images that were missing rulers were radiographic films that were scanned in to a digital format by the practitioner at an unknown resolution and so the DPI could not be obtained. Consequently, attempts were made to use other imaged structures for millimetric reference. In 3 images, a mid-sagittal forehead positioner was present and the known width of the positioner was measured. Since mid-sagittal structures tend to undergo very little magnification, this was considered an accurate ruler surrogate. Fifteen images contained neither a ruler nor a forehead positioner. For these images, the mesio-distal width of the first mandibular molar was used as a millimeter reference since this structure can generally be well visualized and is also close to the midline. Although we attempted to determine a reasonable average molar size based on both published norms and on an average derived from 20 archived cases at the University of Washington, the actual molar width of the patient may have varied from the molar average that we used. In our own sample of 20 patients, the majority of molars were around 11.5 mm, however the outliers were 10mm at the smallest, and 13 mm at the largest. Should the patient's actual molar size differ greatly from the average of 11.5 mm that we used, there may be slight inaccuracies in the millimetric measurements on that patient's cephalometric analysis. To ensure that inclusion of these millimetric points did not skew the sample trends, a sensitivity analysis was performed excluding the estimated sample. Since this analysis demonstrated no difference in sample trends whether the patients were included or not, the millimetric measurements from these patients were kept in the final analyses.

Although the study is being performed on orthodontists and patients currently engaged in active treatment, the study questions ask for impressions, goals, and expectations present before the start of treatment. As a result, there may be recall bias, especially if either party has adjusted their perspective relative to how the treatment has proceeded thus far. Furthermore, we only asked the practitioner how often they believed themselves to prescribe a certain type of treatment for AOB. Although the practitioners responded to this question to the best of their ability, a practitioner's perceived vs. actual practice trends may differ slightly.

Care should be taken in extrapolating the findings from this study to the entire population of practitioners treating AOB in the United States. While an attempt was made to sample doctors from across the country of different backgrounds and in different practice settings, our sample consisted of a high percentage of private practice, Caucasian, male orthodontists from the western region. Only 3 general practitioners participated. We had small numbers of participating orthodontists of Hispanic and multiracial descent and no participating orthodontists of Black/African American descent. Bias in the sample could also occur if the NDBPRN only attracted a certain type of orthodontist that deviated from the average US orthodontist in terms of educational background, clinical beliefs, degree of conservativeness, etc. Bias might also occur if practitioners purposely elected to enroll only those patients whose treatment appeared to be going well.

Chapter 5. CONCLUSIONS

The purpose of this study was to evaluate which patient and practitioner characteristics, if any, influenced treatment recommendations and acceptance rates for current cases of AOB being treated in the United States. This evaluation was performed by obtaining patient and provider demographics and patient dentofacial characteristics via surveys administered through the NDPBRN as well as through the collection of initial diagnostic information and pre-treatment cephalograms. The following conclusions were drawn from statistical analysis of the patient and provider characteristics in association with treatment plan recommendations and acceptances:

PATIENT DENTOFACIAL CHARACTERISTICS:

1. Mandibular plane angle, initial overbite and molar classification were all independently associated with a surgical recommendation: With increasing mandibular plane, worsening open-bite and the presence of Class II molars, practitioners were more likely to recommend surgery as the primary treatment option for AOB.
2. Patients that were recommended surgery tended to have a more severe open-bite. Surprisingly, the mean severity of open-bite was very similar (within 0.5 mm) among patients that were recommended TADs and patients recommended aligners/fixed appliances as the primary treatment option.

PATIENT DEMOGRAPHICS

3. There were no differences in treatment plan acceptance rates based on patient age, gender, or education level
4. Patient acceptance rates were nearly identical for extraction and non-extraction treatment plans
5. Of those patients who were recommended surgery as the primary treatment option, the acceptance rate was 30% better on average for those patients with medical or dental insurance that covered surgery compared to those without insurance coverage.

PRACTITIONER DEMOGRAPHICS

6. Overall, there were few detectable trends in practitioner treatment planning of AOB based on demographic characteristics—Of significance, a higher percentage of practitioners who attended dental school outside the United states and were of Asian descent often prescribe TAD treatment for AOB.

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