A Cephalometric Analysis of Vertical Incisor Positioning When Treating Adolescents with Deep Bites Utilizing Fixed Edgewise Orthodontic Appliances

By
JOSHUA WIGGINS DDS, MHS

Mark G Hans DDS MSD, Juan M Palomo DDS MSD, Ali Syed BDS MS

Submitted in partial fulfillment of the requirements for the degree of
Master of Science in Dentistry

Department of Orthodontics

CASE WESTERN RESERVE UNIVERSITY

Graduation December 2025

CASE WESTERN RESERVE UNIVERSITY

SCHOOL OF DENTAL MEDICINE

GRADUATE STUDIES

We hereby approve the thesis of

Joshua Wiggins

Candidate for the degree

Master of Science in Dentistry

Signed: DocuSigned by: Mark G Hans 2F343C277FC6467...

Mark G Hans - Thesis Advisor

Signed by: Juan M Palomo 425B082644AD404...

Juan M Palomo

DocuSigned by: Ali Syed 50DBFFE875244F4...

Ali Z Syed

Date: 12/16/2025

DEDICATION

I dedicate this thesis to my parents, family and the entire village of individuals who poured their time energy and investment into the individual blessed enough to present this study as his thesis defense. Your time and energy has not gone unnoticed and can never be forgotten.

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Acknowledgements

For the guidance, support and patience provided to me by my thesis supervisor Dr. Mark Hans, I am truly grateful for time and contributions throughout this process. To my thesis committee, Dr. Juan Palomo and Dr. Ali Syed, I am eternally grateful for your expertise and efforts in shaping this study.

List of Abbreviations

Anterior Nasal Spine (ANS): most anterior point of the bony projection of the maxilla

Bolton Brush Growth Center (BBGC): Bolton Brush Growth Center

Center of Resistance (CR): point located at a distance of 33% of the root length, when measured from the alveolar crest

Maxillary Skeletal Change (MXSK): vertical distance between the location of the ANS at pretreatment and posttreatment

Bodily Movement of Maxillary Incisor (BUI): vertical distance between the ANS and CR of the upper incisor

Tipping Movement of Maxillary Incisor (TUI): vertical distance between CR and incisal edge of the upper incisor

Tipping Movement of Mandibular Incisor (TLI): vertical distance between CR and incisal edge of the lower incisor

Bodily Movement of Mandibular Incisor (BLI): vertical distance between the ANS and CR of the lower incisor

Mandibular Skeletal Change (MNSK): vertical distance between ANS and menton

Overbite (OB): vertical distance between the incisal edge of the upper incisor and incisal edge of the lower incisor

Change in Overbite (D**OB):** summation of changes in all variables (MXSK, BUI, TUI, TLI, BLI, MNSK)

Change in Anterior Facial Height (D**AFH):** sum of the changes in MXSK and MNSK

Vertical Incisor Position (VIP): Position of the maxillary and mandibular incisors in the vertical dimension

Abstract

Introduction: Vertical Incisor Positioning (VIP) is paramount when concerning the esthetics of a beautiful smile and are of increased concern when treating patients diagnosed with a deep bite. This study aims to isolate the effects of fixed edgewise orthodontic appliances on deep bite adolescent's incisor positioning in the vertical dimension when isolated for observed and expected growth compared to the VIP of adolescents who were not treated orthodontically.

Methods: This retrospective study was conducted utilizing landmarks from the novel Case Western Reserve University Vertical Analysis to assess a sample of before and after lateral cephalograms extracted from original 3D Cone Beam Computed Topography (CBCT) imaging on patients aged 10-18 in Case Western Reserve's Orthodontic Clinic. All patients were treated nonextraction and exclusively with fixed edgewise orthodontic appliances. Samples were classified and matched to controls from the Bolton Brush Growth Center (BBGC) by age and sex.

Results:

Thirty treated subjects were matched 1:1 with controls from the Bolton-Brush Growth Center based on age, sex, and Angle Classification. Using the CWRU Vertical Analysis, skeletal vertical measures showed no significant differences between groups indicating that fixed edgewise appliances did not produce measurable skeletal vertical alterations. In contrast, all dental components exhibited statistically significant treatment effects. The composite change in overbite showed a highly significant difference, confirming that

deep-bite correction resulted overwhelmingly from dentoalveolar adaptation, not skeletal change. These findings reinforce the growing consensus that vertical correction with conventional fixed appliances in adolescents is achieved primarily through controlled incisor movement rather than modification of vertical skeletal structures.

Conclusion:

Deep-bite correction with fixed appliances is predictable without the need for vertical auxiliaries, provided torque control and leveling are executed correctly. Skeletal vertical changes should not be expected when using fixed appliances alone and clinicians must rely on incisor mechanics to achieve vertical goals. The relative contributions of BUI, BLI, TUI, TLI should guide treatment planning, especially in hypodivergent patients or those with short lower facial height. The data supports a mechanically efficient, inventory-light approach to deep-bite treatment—highly relevant in modern, esthetically driven orthodontic practice.

Review of the Literature

Evidence-based Orthodontics and the clinicians who utilize this concept are constantly posed with the challenge of blending the precisely objective science of tooth movement and biomechanical principles with the concepts of an increasingly esthetically, and by virtue subjectively, driven discipline in daily practice. It is the aim of this study to contribute to the quantification and objectification of esthetic goals; with particular emphasis on incisor positioning, vertical incisor display, and smile arc when treating deep overbite cases in growing adolescents as determinants of facial harmony. Control of the vertical dimension is central to achieving a balanced and esthetically pleasing outcome, especially in the correction of deep bite and open bite malocclusions. Despite abundant research on overbite correction, there remains limited evidence isolating the vertical effects of fixed orthodontic edgewise appliances on maxillary and mandibular incisors compared with untreated growth controls. The following review synthesizes available literature on normal vertical growth patterns, appliance-induced changes, treatment timing, and stability, with focus on how edgewise appliances influence incisor positioning in adolescent patients with Class I and Class II malocclusions.

Normal Vertical Growth and the Bolton-Brush Studies

The Bolton-Brush Growth Study, initiated in 1929 and later expanded into a computerized database, remains one of the most comprehensive longitudinal investigations of normal dentofacial growth (Hans, Broadbent, & Nelson, 1994). Over 4,300 subjects were followed with serial cephalograms, dental casts, and hand-wrist films, providing unmatched normative data on craniofacial development. Findings highlighted that vertical facial increases are primarily driven by ramus elongation and posterior tooth eruption, while deficiencies in ramus height are closely correlated with excessive anterior overbite (Wylie, 1946). This collection also serves as the control database for many contemporary comparative orthodontic studies, allowing precise isolation of treatment effects against natural growth.

Experimental Evidence of Vertical Dimension Changes

The mechanisms underlying bite opening have long been debated. Bahador and Higley (1944) used cephalometric analysis to examine patients treated with bite plates and concluded that opening was not solely due to mandibular incisor intrusion, but also reflected posterior adaptations and skeletal remodeling. Menezes (1975) corroborated this, finding that posterior eruption rather than significant incisor depression accounted for most of the observed reduction in deep overbite. In a controlled animal study, McNamara (1977) demonstrated that artificially induced increases in vertical dimension produced adaptations beyond the dentoalveolar region, including condylar remodeling and gonial angle changes. These findings confirm that orthodontic alterations of vertical dimension affect both skeletal and dental structures.

Treatment Approaches to Deep Bite Correction

Engel et al. (1980) summarized four main modalities for deep bite correction: (1) posterior eruption with mandibular clockwise rotation, (2) incisor intrusion, (3) labial incisor proclination, and (4) molar extrusion. Their long-term data showed that cases finished with interincisal angles between 125° and 135° demonstrated the greatest stability, while brachyfacial patients with short lower facial height exhibited higher relapse tendencies. Similarly, Atherton and Lovius (1972) contrasted removable appliances with fixed appliances. While removable appliances provided efficient early-stage corrections, they were limited to tipping movements and lacked precision in torque and bodily intrusion. Fixed appliances, by contrast, permitted greater vertical control of incisors and more reliable long-term outcomes.

Influence of Treatment Timing

The timing of deep bite correction significantly impacts both magnitude and stability of results. Baccetti et al. (2012) compared early treatment during the mixed dentition with pubertal-phase intervention and found that overbite reduction was significantly greater in the pubertal group

(–3.1 mm) compared with the prepubertal group (–1.4 mm), with 92% of pubertal patients maintaining correction one year post-treatment. Franchi et al. (2011) conducted a prospective controlled study of two-phase treatment. They reported a net overbite reduction of –1.9 mm compared with untreated controls, with correction largely attributed to proclination of maxillary incisors (4.1°) and advancement of mandibular incisors (2.0 mm), rather than skeletal vertical alterations. These findings reinforce that while pubertal timing maximizes stability, dental movements remain the predominant mechanism of deep bite correction.

Appliance Effects on Vertical Incisor Positioning

Specific appliance systems differentially influence vertical incisor changes. Bazzucchi et al. (1999) demonstrated that AVC treatment followed by fixed appliances significantly increased overbite relative to controls. The correction resulted from small but meaningful vertical adaptations, including mandibular autorotation, molar intrusion, lingual incisor tipping, and bodily incisor movement toward the occlusal plane. Hans et al. (2006) compared extraction of first molars versus first premolars using edgewise mechanics. The premolar extraction group exhibited approximately 4.1 mm of true incisor intrusion and overbite reduction, while the molar extraction group achieved only 2.1 mm of overbite correction, primarily due to incisor extrusion and tipping. Notably, neither group demonstrated increases in mandibular vertical height. These studies suggest that fixed edgewise appliances, particularly in extraction protocols, permit controlled bodily intrusion of anterior teeth—a distinction not achievable with removable systems.

Long-Term Stability and Relapse

Relapse remains a central challenge in vertical correction. In a 10-year postretention study, Simons and Joondeph (1973) reported that overbite reductions achieved during the pubertal growth spurt were largely maintained, whereas early corrections tended to relapse. Engel et al.

(1980) confirmed that stability was greatest when incisors were finished within physiologic interincisal angle ranges and when correction relied on true intrusion rather than mandibular clockwise rotation.

Growth, Sutural Adaptation, and Skeletal Considerations

The complexity of growth in the palatomaxillary region further complicates vertical control. Melsen and Melsen (1982) used autopsy material to show that the palatal bone functions as a 'buffer' between cranial base and maxillary growth, with sutural interdigitation increasing rigidity through adolescence. This finding underscores the difficulty of producing skeletal vertical change after early adolescence, reinforcing the importance of timely intervention.

Synthesis and Knowledge Gap

Collectively, these investigations establish that growth-driven vertical changes primarily occur via ramus elongation and posterior eruption (Wylie, 1946; Hans et al., 1994). Fixed orthodontic appliances, especially when combined with premolar extractions, enable true anterior incisor intrusion and greater vertical control compared with removable appliances (Atherton & Lovius, 1972; Hans et al., 2006). Timing of treatment at puberty maximizes stability (Baccetti et al., 2012; Simons & Joondeph, 1973). Relapse tendencies are reduced when corrections are achieved through incisor intrusion and physiologic interincisal angulation (Engel et al., 1980). Despite these insights, few studies have directly compared vertical incisor positioning in treated adolescents with untreated growth-matched controls. The Bolton-Brush Collection uniquely enables such comparisons, addressing a critical gap in understanding how edgewise appliances alter the vertical dimension of incisors beyond normal growth patterns.

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Statement of Thesis

The purpose of this study is to investigate the relationship between the vertical incisor position (VIP) of growing male and female adolescent patients diagnosed with deep overbite malocclusion whom were treated exclusively with fixed Edgewise orthodontic appliances. This study compared the VIP of these treated cases from a control of adolescent patients who have received no orthodontic treatment in order to determine the effect of fixed edgewise orthodontic appliances in the vertical dimension.

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Joshua Dewade Wiggins D.D.S., M.H.S

Resident, Department of Orthodontics

Case Western Reserve University, Cleveland OH

jdw181@case.edu

Juan Martin Palomo D.D.S., M.S.D.

Faculty and Program Director, Department of Orthodontics

Case Western Reserve University

Palomo@case.edu

Ali Syed B.D.S. M.S.

Faculty, Department of Oral and Maxillofacial Medicine and Diagnostic Sciences

Maxillofacial Radiologist

Ali.Z.Syed@case.edu

Mark Hans, D.D.S, M.S.D. (Corresponding Author)

Faculty and Department Chair, Department of Orthodontics

Case Western Reserve University

Mark.Hans@case.edu

Introduction

Orthodontics is an increasingly esthetically driven field of dentistry, where the success of treatment is no longer judged solely on the achievement of ideal occlusal relationships, but equally on harmony of the smile and facial esthetics. Among the many components of dentofacial balance, the vertical dimension of the incisors plays a pivotal role. Proper vertical positioning of the maxillary and mandibular anterior teeth determines not only the mechanics of occlusion but also the smile arc, incisor display at rest, and the dynamic esthetics of facial animation.

Vertical incisor positioning is closely tied to perceptions of youthfulness and attractiveness. Studies in esthetic dentistry have consistently shown that a smile displaying 1–3 mm of maxillary incisor below the relaxed upper lip conveys vitality and energy, whereas excessive gingival display can appear less harmonious, and insufficient incisor show contributes to an aged appearance. The gingival margin display during smiling has similarly been associated with positive esthetic evaluations when limited to approximately 1–2 mm, beyond which “gummy smiles” may be judged less favorably. Conversely, inadequate incisor display at rest—particularly in younger patients—detracts from an esthetically pleasing outcome.

The vertical dimension of anterior teeth is not only a determinant of smile esthetics but also a functional cornerstone in managing malocclusions. In cases of deep bite, excessive vertical overlap of incisors can compromise proper anterior coupling, resulting in traumatic occlusal contacts, palatal wear, or restricted mandibular movements.

Conversely, in open bite malocclusions, insufficient vertical overlap leads to the loss of anterior guidance, speech difficulties, and functional inefficiency. Orthodontic treatment, therefore, must carefully balance esthetic demands with the need for proper incisal relationships.

The orthodontic literature highlights multiple mechanisms of overbite correction, including posterior eruption, incisor intrusion, incisor proclination, and molar extrusion (Engel et al., 1980). The clinician's ability to control anterior vertical positioning directly impacts the stability of treatment outcomes. Excessive reliance on posterior extrusion may result in mandibular clockwise rotation and relapse, while controlled incisor intrusion within fixed edgewise appliances has been associated with more stable corrections (Hans et al., 2006).

A persistent challenge in evaluating the effect of orthodontic therapy on vertical incisor positioning is separating true treatment effects from changes attributable to normal growth. The Bolton-Brush Growth Study established normative patterns of dentofacial development in over 4,000 subjects, documenting that increases in lower anterior facial height and posterior tooth eruption are expected components of adolescence (Hans, Broadbent, & Nelson, 1994). However, deficiencies in ramus height and intermaxillary space have been linked with excessive deep bite (Wylie, 1946), suggesting that orthodontic correction must operate within biologic limits. The availability of untreated longitudinal growth controls from the Bolton-Brush Collection uniquely enables direct comparison of treated and untreated individuals, isolating the specific impact of appliance mechanics from normal growth adaptation.

The esthetic role of vertical incisor positioning extends beyond static measures. During facial animation, incisor display and smile arc curvature significantly influence perceptions of attractiveness. A consonant smile arc—where the incisal edges of maxillary anterior teeth follow the curvature of the lower lip—has been rated as more youthful and dynamic compared with flat or reversed arcs. Similarly, proper incisor positioning ensures balanced gingival display, with excessive gingival margin show considered unaesthetic, while slight exposure enhances vibrancy. These esthetic standards underscore why orthodontic treatment planning must integrate vertical incisor control into the design of fixed appliance therapy.

Fixed edgewise appliances provide the biomechanical versatility required to control the vertical position of incisors with precision, offering advantages over removable appliances that primarily produce tipping movements (Atherton & Lovius, 1972). With appropriate archwire selection, anchorage preparation, and use of extraction mechanics when indicated, edgewise appliances can achieve bodily intrusion of anterior teeth, control of torque, and long-term stability of vertical corrections. The distinction between extrusion-driven correction and true incisor intrusion is especially important in achieving esthetically stable outcomes.

Despite extensive clinical emphasis on correcting deep bite and open bite malocclusions, relatively few studies have quantified the vertical changes of incisors during fixed appliance therapy compared with untreated adolescent growth. Prior literature often relied on cephalometric comparisons without matched controls, making it difficult to discern whether observed changes were due to orthodontic mechanics or normal developmental patterns.

The purpose of this study, “The VIP to your Smile; a cephalometric analysis of vertical incisor positioning in fixed Edgewise Orthodontic Appliances,” is to evaluate the extent to which fixed orthodontic appliances alter vertical incisor position relative to growth-matched controls from the Bolton-Brush Growth Study. By isolating treatment effects from natural growth, this research aims to clarify the role of incisor intrusion, extrusion, and vertical adaptation in orthodontic therapy, and to highlight their implications for both functional occlusion and esthetic outcomes.

Materials and Methods

This retrospective cohort study analyzes the results of orthodontic treatment on 30 adolescents taken from the records of patients treated at Case Western Reserve University’s Orthodontic residency program. This study was approved as a modification (00040933) to the original approved study (20231439) by the Institutional Review Board at Case Western Reserve University.

Sample

1067 participants were selected for review from the patient population treated at Case Western’s Orthodontic Residency clinic. Inclusion criteria included adolescents aged 11-18 treated with fixed edgewise appliances using the MBT prescription with 0.022 x 0.028-inch sized brackets. Selected participants were not to be treated with extractions, fixed or removable expanders, fixed functional orthopedic appliances, removable functional orthopedic appliances, vertical correctors, bite blocks, props or

turbos, intrusion arches, segmented archwire mechanics, temporary anchorage devices (TADs) or individuals treated with aligner therapy. Round and rectangular archwires of nickel titanium, stainless steel, and titanium- molybdenum alloy were used throughout treatment. Elastics were used to correct anteroposterior discrepancies. Patients with insignificant radiographs for diagnoses, a history of craniofacial syndromes or being prepared for orthognathic surgery were excluded from this study. 30 patients satisfied the inclusion criteria stated above. 30 control samples were then matched by age, sex and angles classification using the digital libraries of the Bolton Brush Growth Center's (BBGC) legacy collection.

Image Collection

Corresponding pre and post-treatment lateral cephalograms from the treated sample were extracted from 3D Cone Beam Computed Topography (CBCT) utilizing Dolphin imaging software with subjects' placed in their natural head position and biting in centric occlusion. Extracted Lateral cephs were taken in an orthogonal projection with 0% magnification and oriented at the mid-sagittal line. Pre and post treatment cephalograms were aptly labeled as timepoints 1 (T1) and 2 (T2) respectively. Control subjects were scanned with a film digitizer (VIDAR DosimetryPRO Advantage, Vidar Systems Corp., Herndon, VA) and digitally enhanced for clarity using RGX wizard imaging software. One investigator (JW) performed all constructions.

Technical Details

One investigator (JW) traced all images digitally using the aforementioned imaging software (Dolphin version 13.0). All landmarks were identified on each cephalogram utilizing the novel Case Western Vertical Analysis. The CR was arbitrarily established as 33.3% of the distance between the alveolar crest and the root apex of the incisors. The following landmarks were digitized: Anterior Nasal Spine (ANS), Sella, Nasion, Orbitale, Porion, A point, B Point, Basion, Root Apex of the maxillary and mandibular incisors(U1 Root, L1 Root) center of resistance of the maxillary and mandibular central incisors (U1COR, L1COR), incisal edges of the maxillary and mandibular central incisors (U1Tip, L1Tip), and menton (Me). T1 and T2 images were superimposed digitally based on the anterior cranial base structures suggested by the American Board of Orthodontics such as the anterior wall of sella, the greater wing of sphenoid, and the ethmoid triad. This digital method was previously formatted by Elbarnashawy, who converted the manual traced version of the CWRU cephalometric analysis in other studies. The Dolphin imaging software automatically formulates a Cartesian coordinate system for the superimpositions with the origin point (0,0) coincident at orbitale (Or).

Convention of Signs

All linear and angular measurements in this analysis were calculated using a standardized convention of signs to ensure consistent interpretation across variables with one operator (JW) performing calculations. For vertical measurements, all values are referenced to the Sella–Nasion (SN) plane, serving as the stable cranial base reference. In this system, negative vertical values denote an inferior movement away

from the Sella–Nasion line, corresponding to downward displacement or extrusion of dental or skeletal landmarks. Conversely, positive vertical values indicate a superior movement toward the Sella–Nasion plane, representing upward displacement or intrusion.

From an anteroposterior perspective, all angular and linear incisor measurements are referenced to their respective skeletal bases and perpendicular axes. Positive values indicate anterior tipping or proclination, reflecting labial inclination or forward movement of the incisal edge. Negative values correspond to posterior tipping or retroclination, indicating lingual inclination or backward movement relative to the cranial reference.

All changes are expressed as T2 minus T1 values, with the directionality of sign conventions preserved across the maxillary (MXSK, BUI, TUI) and mandibular (MNSK, BLI, TLI) components. This reference framework ensures that vertical and angular movements are interpreted uniformly for both control and treated samples, facilitating accurate isolation of appliance-induced effects versus growth-related adaptations. These conventions will serve as the definitive reference for all subsequent analyses and graphical representations of the data.

Statistical Analysis

The shapiro-Wilk test was utilized to assess distribution of each variable of raw data and descriptive analyses were assessed to evaluate the matching of treated to

control samples by sex, age and angles classification. A p-value of 0.05 was used to assign statistical significance.

Error Study

Errors within the digitization of lateral cephalograms for each group were assessed by randomly selecting ten subjects, 5 from each respective group, to be traced again at T1 and T2 intervals. The two sets of tracings and measurements were compared using intraclass correlation coefficients.

Results

As described in table 2, thirty subjects, comprised of 15 males and 15 females between the ages of 11-18, were included in both the treated and control groups through selection matching from original records cultivated from the Bolton-Brush Growth Center. The treated group consisted of 11 Class I and 19 Class II cases. Each case was matched with a corresponding control of identical age, sex and Angle Classification. The mean age of the sample prior to treatment (T1) was 13.81 ± 1.23 years, was matched closely with the control group at 13.75 ± 1.28 years, confirming chronological age equivalence between groups. Samples were then matched, based on sex and angle classification, with their corresponding controls.

Analysis of the vertical components of deep overbite correction using the CWRU Vertical Analysis demonstrated clear and distinct statistically significant dental effects, while skeletal vertical changes did not show a significant difference from the normal growth observed in the matched control group. Maxillary skeletal change (MXSK Diff) showed no significant difference between treated and control groups ($t = 0.5906$, $p =$

0.5586). These findings indicate that fixed edgewise appliances did not produce maxillary vertical skeletal alterations beyond those observed in untreated controls. Similarly, mandibular skeletal change (MNSK Diff) showed no meaningful difference ($t = 0.2627$, $p = 0.7938$), reaffirming that the vertical skeletal change was comparable to natural growth.

The dental components however demonstrated statistically significant differences in favor of the treated group in comparison to the controls. Bodily maxillary incisor movement was demonstrably greater in the treated subjects ($t = 5.7434$, $p = 0.0004$), confirming that vertical displacement of the maxillary incisors as a result of fixed edgewise appliances is an important contributor to overbite correction. Maxillary incisor tipping was also statistically significant($t = –2.7464$, $p = 0.00854$), indicating labiolingual tipping was observed in greater capacity in treated subjects.

Mandibular incisor changes exhibited a similar pattern of significant change as their maxillary counterparts in the treated group. Bodily movement of the mandibular incisors was significantly greater in the treated group ($t = 2.8804$, $p = 0.00632$), and mandibular incisor tipping also differed significantly between groups ($t = 2.4004$, $p = 0.02128$). These findings establish that both upper and lower incisors exhibited treatment-dependent vertical and angular rotational changes, consistent with the biomechanical expectations of deep-bite correction with fixed appliances.

Finally, the composite measure of vertical overbite change demonstrated a highly significant treatment effect ($t = 12.3992$, $p = 1.62 \times 10^{-13}$), confirming that the combined

dental contributions resulted in a drastically superior overbite correction in treated subjects compared with their matched controls.

When combined, these results indicate that deep-bite correction in this study was achieved almost exclusively by dentoalveolar changes; specifically maxillary and mandibular incisor movement, while skeletal vertical changes remained equivalent to normal developmental growth patterns. This pattern aligns with historical and contemporary literature emphasizing the dental nature of vertical correction in adolescents treated with conventional fixed edgewise appliances.

Discussion

Across all variables, the skeletal components of the between-group p-values did not reach statistical significance. This indicates that the vertical skeletal movements observed during fixed edgewise appliance treatment were not considered an important factor in the changes observed. This is further confirmed as these changes are comparable to those occurring naturally in the matched, untreated controls during the same age intervals. Conversely, significant values were observed in the dental components between group comparisons with the most significant change occurring in the change in overbite followed by the bodily movement of the upper incisors and tipping of the lower incisors. Of note, there was also some significance denoted to the tipping of upper incisors and bodily movement of the lower incisors. These findings suggest that, when growth is properly controlled for, fixed edgewise appliances alone do generate large or isolated dental changes, and that overbite correction arises from a

combination of multifactorial components with an emphasis on treatment-specific effects including Tipping of the Lower Incisors and Bodily movement of the Upper Incisors. This effectively proves the hypothesis of this study that fixed orthodontic treatment had a significant impact, when controlled for mandibular growth, on the vertical position of incisors when treating deep bite patients.

Limitations

Limitations to this study can be attributed to differences in bone physiology and patients who underwent treatment in different phases of growth and pubescence. 11 patients were treated with an initial class I malocclusion and therefore had minimal interarch elastic use that could affect the vertical position and inclination of the incisors. Conversely, interarch elastics were used in conjunction with other biomechanical principles that could also have an effect on the vertical incisor position. Secondarily, the age of the female subjects in this study could have an effect on expected mandibular growth left in the vertical dimension. While this study does provide insight into the effects of fixed edgewise treatment on patients with deep overbite, more research is needed to definitively quantify its effects.

Conclusion

In conclusion, treatment of deep overbite cases with Fixed Edgewise Orthodontic Appliances in this study exhibited statistically significant effects on Dentoalveolar movements in the vertical dimension with no significant effects attributed to the skeletal growth component of treatment of patients with deep overbite.

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Figures

I. Schematic Diagram of skeletal and dental variables

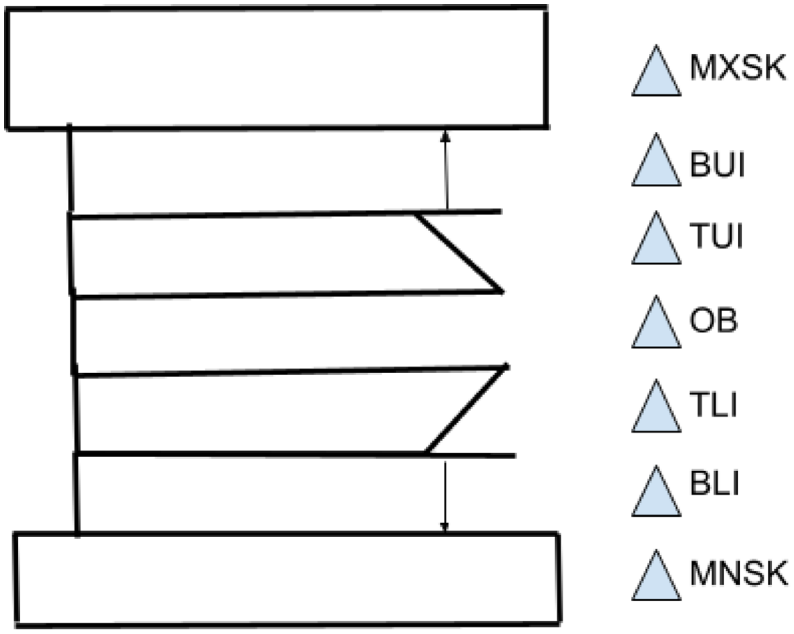


FIGURE 1

II. Schematic Diagram showing the Overall Net Change in variables between Both Treatment Groups

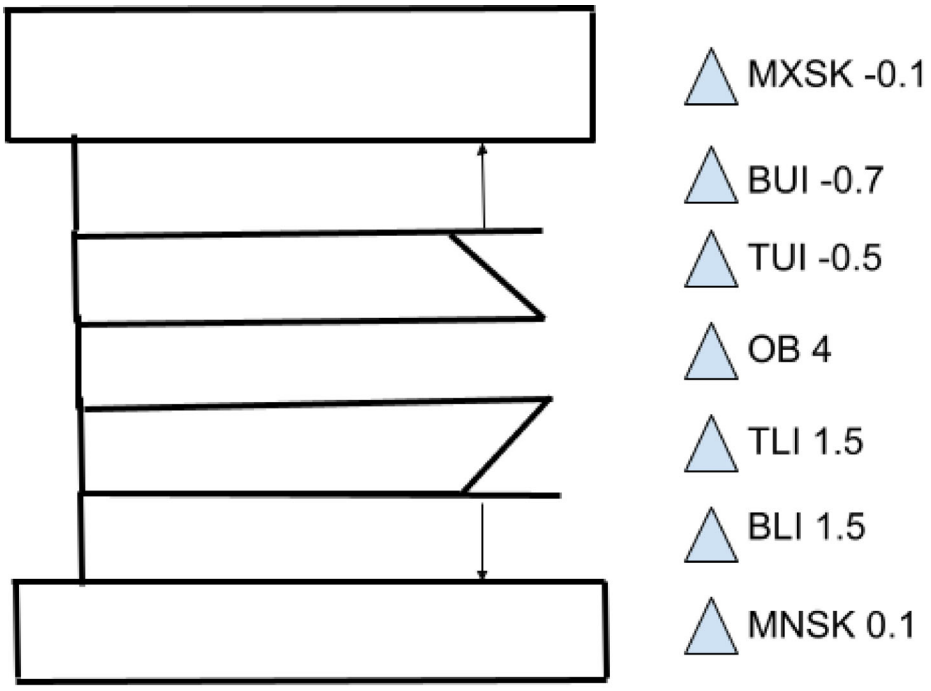


FIGURE 2

Tables

I. Means and Standard Deviation of CWRU Vertical Analysis Variables

Variable	Control Means	Treated Means	P Value	Significance
MXSK	-2.27 ± 0.21	-2.33 ± 0.47	0.5586	NS
BUI	-1.46 ± 1.22	0.72 ± 1.68	0.000463	*
TUI	-0.46 ± 0.95	-1.01 ± 0.55	0.00854	*
BLI	-1.97 ± 1.14	-0.53 ± 2.49	0.00632	*
TLI	0.08 ± 0.65	1.58 ± 1.55	0.02128	*
MNSK	3.20 ± 1.29	3.31 ± 1.73	0.7938	NS
OB	0.44 ± 0.31	4.39 ± 1.72	0.0000000162	*

II. Description of Treated and Control Groups

	Treated	Control
Total Sample	30	30
Girls	15	15
Boys	15	15
Angle Class I	11	11
Angle Class II	19	19
Age T1	165.8 (13.81 Years)	165.0 (13.75 Years)
Age T2	198.0 (16.5 Years)	199.3 (16.6 Years)
Time Interval	32.34 (2.7 Years)	34.69 (2.89 Years)

III. Age in M & Y

CONTROL	T1 (M)	T1 (Y)	T2 (M)	T2 (Y)
Mean	165.0	13.75	199.3	16.6
Std Dv	15.3	1.275	14.75	1.23

TREATED	T1 (M)	T1 (Y)	T2 (M)	T2 (Y)
Mean	165.8	13.81	198.0	16.5
Std Dv	14.6	1.23	13.4	1.13

IV. Average Length of time under observation measured in M & Y

	TX TIME (M)	TX TIME (Y)	STD DEV (M)	STD DEV (Y)
CONTROL	34.69	2.89	10.7	.9
TREATED	32.34	2.7	8.68	.7

IRB APPROVAL

