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CLASS III CORRECTION USING CLEAR ALIGNER THERAPY IN ADULT PATIENTS

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Class III correction using clear aligner therapy in adult patients

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Masters of Science in Dentistry

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ABSTRACT

Introduction: This study was designed to analyze the cephalometric changes in adult Class III malocclusion treated with clear aligner therapy. **Methods:** In this retrospective study, thirty-six Class III adult patients treated with clear aligner therapy in private practice and a graduate orthodontic clinic were included in this study. Inclusion criteria included patients aged 18 years and older, Class III molar relationship that is end-on or greater, at least one anterior tooth that is in crossbite or incisors in an edge-to-edge bite, and complete records (initial and final lateral cephalograms) that are clear and traceable. Twenty-two cephalometric measurements were measured and analyzed by two calibrated judges. Results were categorized by skeletal vertical, skeletal anterior-posterior, dental vertical, and dental anterior-posterior. Descriptive analysis for mean, standard deviation, range, and percent was completed for demographic information, a paired *T* test to determine pretreatment and posttreatment cephalometric differences was performed, and a chi-square test for proportions was conducted. **Results:** No vertical changes were noted in upper and lower molar positions, and the upper incisor inclinations were maintained. On the other hand, lower incisors retroclined on average 5.6 degrees and retracted 1.78 mm. There was no change in the mandibular plane angle across different vertical pattern groups (normodivergent/hypodivergent/hyperdivergent patients). The only cephalometric variable that was statistically significant between different vertical pattern growers was the overbite. **Conclusions:** Adult patients with Class III malocclusion treated with clear aligners have good vertical control with no increase in mandibular plane angle and anterior face height. Clear aligner therapy is also good at maintaining vertical control for hyperdivergent patients. Finally, adult Class III dental camouflage treatment was resolved primarily through maintaining upper incisor inclination and lower incisor retroclination.

INTRODUCTION

Class III malocclusion in orthodontic patients is known to be challenging to treat, demanding careful evaluation and targeted implementation of effective treatment mechanics to achieve successful outcomes. By definition, Angle's classification of malocclusion describes Class III patients as those who present with a dentoalveolar relationship where the mesiobuccal cusp of the maxillary first permanent molar is posterior to the buccal groove of the mandibular first permanent molar. Skeletal Class III malocclusion, on the other hand, is characterized by maxillary retrognathia, mandibular prognathism, or can be a result of the combination of these two features. Orthodontic management of Class III malocclusion can range from early orthopedic correction in growing patients, to orthodontic camouflage and/or surgery in non-growing patients depending on the severity of the underlying skeletal Class III pattern.[7] Aside from the patients who present with the most severe Class III skeletal patterns, many patients prefer not to consider a surgical treatment plan and will opt for orthodontic correction alone where function and aesthetics may be improved.[9]

Treatment planning and management of adult Class III patients seeking orthodontic camouflage to mask the underlying skeletal discrepancy can pose a difficult feat for clinicians. The complexity oftentimes lies in need to not only address an anterior-posterior malalignment but an additional vertical component of malocclusion. The presentation of a Class III malocclusion may include an anterior open bite, edge-to-edge bite, and/or a hyperdivergent growth pattern. which collectively demand careful control in the vertical dimension. Ineffective vertical control during comprehensive orthodontic treatment can pose significant and adverse effects, including the mandibular plane rotating downward and backward, opening of the bite, and potentially exacerbating facial aesthetics. Such cases oftentimes result in compromised treatment objectives with longer treatment time needed for corrective intervention.

In contrast to fixed appliance therapy, clear aligners have been reported to be an effective orthodontic treatment modality for vertical control. Since its official introduction by Align Technology in 1998, clear aligner therapy has become an increasingly popular and rapidly advancing orthodontic treatment of choice to resolve a wide spectrum of malocclusions.[2] While fixed appliance therapy is known to extrude the teeth and increase the mandibular plane angle during treatment,[1, 8] clear aligners can program intrusive forces accordingly and concomitantly utilize the full occlusal coverage to maintain vertical control. Numerous studies conducted have demonstrated the effectiveness of clear aligner therapy in controlling the vertical dimension, particularly advantageous for the correction of Class III malocclusion. In the study by Khosravi,[5] cephalometric analysis results revealed the primary mechanism by which open bite and deep bite correction occurred utilizing the Invisalign appliance was through incisor movement, with the molar vertical position exhibiting minimal change.

Despite studies illustrating advantageous vertical control with the clear aligner system, there is a dearth of scientific literature available surrounding its treatment effects in the correction of Class III malocclusion. Case reports have been published however, much remains to be investigated. Thus, the purpose of our investigation is to study the cephalometric changes found in adult Class III patients using clear aligner therapy. We are specifically looking at the mandibular plane angle and occlusal plane changes in the vertical dimension and the incisor position and inclination changes in the anterior-posterior dimension. Our hypotheses are as follows: 1) Adult patients with Class III malocclusion treated with clear aligners have good vertical control with no increase in mandibular plane angle or anterior face height; 2) There is no difference in changes seen in the mandibular plane angle in normo/hypodivergent patients versus hyperdivergent patients treated by clear aligners; 3) Adult patients with Class III malocclusion treated with clear aligners have no skeletal sagittal correction and result in mainly incisor inclination changes.

MATERIALS AND METHODS

This retrospective study was conducted on Class III adult patients over the age of 18 who received clear aligner treatment in private practice and at the University of the Pacific Graduate Orthodontic Clinic. The clinician in private practice is an American Board of Orthodontics board-certified clinician, similar to the overseeing faculty providing resident instruction at the university. Institutional review board approval was obtained at the University of the Pacific prior to starting the investigation (#20-18).

The criteria for selection included (1) adult patients 18 years and older, (2) clear aligner patients who started and finished treatment in the time spanning from 2011-2021 from both clinics, (3) Class III molar relationship that is end-on or greater and at least one anterior tooth that is in crossbite or edge to edge verified with initial scans, and (4) complete records with initial (T1) and final (T2) cephalometric radiographs. Figure 1 demonstrates the sampling process for both clinics.

A list of adult clear aligner patients from private practice who started treatment between 2011-2021 was generated utilizing the clinician's practice management software program. 728 eligible patient list was generated. From this list, 23 patients met the inclusion criteria and were included in the study. In the Graduate Orthodontic Clinic, a list of 858 clear aligner patients was obtained. Upon applying the inclusion criteria filters, 13 patients remained. The reasons for exclusion are fully recorded (Figure 1), and the final sample consisted of 36 patients from both clinics. Sample size was calculated. A total of 17 patients was needed to achieve a power of 80% and a level of significance of 5% to detect the mean difference of 1.5 mm in overjet changes with a standard deviation of 2. The total of 36 cases in this study demonstrated a sufficient sample size.

Lateral cephalometric radiographs were collected at initial (T1) and final (T2) timepoint for each patient. Two judges were calibrated, and digital tracings of lateral cephalometric landmarks were performed independently for all radiographs. Tracings were completed using Dolphin Imaging software (version 12; Dolphin Imaging, Chatsworth, California), and the final measurements were the average of the two judges' tracings. Figure 2 shows the cephalometric measurements used in this study. The main outcome variables in this study are the cephalometric measurements of the mandibular plane (MP-SN) angle and anterior facial height (AFH), occlusal plane angle changes, U6/L6 and U1/L1 vertical position, and U1/L1 inclination. The U1 vertical position was measured as the perpendicular distance (mm) between the incisal edge of the maxillary central incisor and palatal plane (ANS-PNS). The L1 vertical position was measured as the perpendicular distance (mm) between the incisal edge of the mandibular central incisor and mandibular plane (Go-Me).

To test the second question, patients were categorized by vertical pattern. Individuals who had a MP-SN angle equal to or greater than 38 degrees was categorized as hyperdivergent. Normodivergent and hypodivergent patients were those who presented with an MP-SN of less than 38 degrees.

Statistical Analysis

ICC was calculated to measure the interexaminer reliability. Descriptive statistics were generated to report the mean, standard deviation (SD), range, and percent of the demographic information. Paired *T*- tests were used to determine if pretreatment and post-treatment cephalometric differences were significant. Unpaired *t*-tests were used to compare mean differences while chi-square tests were used to compare proportions. *P*-values of less than 0.05 were considered statistically significant.

RESULTS

The ICC range was from 0.93-1.00 as seen in Table I, indicating excellent interexaminer reliability

The sex distribution by clinic was not statistically significant, with a *P* value of 0.21 (Table II). The total number of males and females in the private practice group were 17 and 6, respectively. Thus, 73.9% were males and 26.9% were females in this group. In the graduate clinic, 7 were males (53.9%) while 6 were females (46.1%).

The mean age in private practice was 33.5 ± 6.5 years while in the graduate clinic the average age was 28.2 ± 7.4 years. The *p* value of 0.03 showed statistical significance, however as the present study includes only adults, this finding is not pertinent to the overall outcome. When we look at the combined mean age, the pretreatment age was 31.65 ± 7.2 years while post-treatment average age was 33.72 ± 7.08 years. For age distribution by sex, the majority of patients were within the 18-40 year age range with 18 males and 12 females There were 8 males and no female patients above the age of 40. Overall, there were more males than females in the patient sample (Fig. 3).

Upon analyzing the patient sample from both private practice and the Graduate Orthodontic Clinic, it was determined that the patients across both clinics were very similar in terms in terms of initial presentation. Out of the 22 cephalometric variables that were traced and compared, only one variable (L1-NB) was different between private practice and the graduate clinic at T1. IMPA values, however, showed no difference. As the majority of the variables were similar, it was decided to combine both sample groups into one sample pool for further analyses.

The changes noted for skeletal anterior - posterior and vertical dimensions (T2-T1) notably showed only SNB, ANB, and Wits values as statistically significant (Table III). SNB and ANB values showed a small reduction which might reflect the influence of lower incisor retroclination on B point. The Wits value revealed a mean increase of 1.14 mm and was highly statistically significant ($P < 0.001$).

For changes in the dental anterior - posterior measurements, there were no significant changes in the upper incisors. All values for the lower incisors, on the other hand, were highly statistically significant ($P < 0.001$). The lower incisors retroclined 5.7 degrees as seen in the L1NB angle and IMPA values while also revealing 1.78 mm of retraction. The interincisal angle and overjet also increased due to the retroclination of the lower incisors. Vertically, there was a mean increase in overbite of 2.44 mm from T1 to T2, which was statistically significant. This was a result of orthodontic camouflage treatment correcting the edge-to-edge bite to a positive overbite. Other statistically significant changes from T2-T1 included slight extrusion of the lower incisors by an average of 0.85 mm as they retroclined and flattening of the occlusal plane by an average of 1 degree.

Analyzing the sample distribution by vertical pattern, there was a total of 20 normo/hypodivergent patients of which 33% were male and 67% of were female (Table IV). Interestingly, this ratio is flipped in the hyperdivergent group where in the total of 16 hyperdivergent patients present, 67% of the patients were female and 33% of males were male. At T1, the following variables were statistically significant: SNA, SNB, ANB, MP_SN, OP-SN-U1SN, U1NA, U1NAd, U1-PP (Table V). T2 had the same statistically significant variables as T1 but included the additional variables of OJ and OB. Of all the cephalometric changes (T2-T1) comparing the differences between normo/hypodivergent and hyperdivergent groups, only overbite had statistical significance with a greater average overbite of 2.2 mm in the hyperdivergent group (Table VI).

DISCUSSION

Clear aligner therapy has become an increasingly popular orthodontic treatment modality amongst patients today. The appeal of this appliance lends itself to improved aesthetics, comfort, oral hygiene, and overall periodontal health.[4] Such features are enticing for all patients including the adult population, who not only look for a comfortable alternative to fixed appliance therapy but seek an appliance that is effective. Various case reports have been published suggesting the successful treatment of adult Class III malocclusion using clear aligners. However, there have been no rigorous studies reported. Acknowledging the scarcity of clinical investigation in the correction of adult Class III malocclusion using clear aligner therapy, the current study was conducted to elucidate the treatment effects of clear aligners in this particular subset of orthodontic patients.

Based on the results of this study, several important points may be deduced. It is notable to recognize that in the present patient sample, there were overall more males than females. This may reflect the fact that males have the tendency for late mandibular growth, thereby contributing to the increased number of adult males seeking Class III orthodontic camouflage treatment later in life. This can also indicate the proclivity and willingness of the male population to undergo dental camouflage while females may prefer surgical correction.

There were noticeable cephalometric comparisons amongst the normo/hypodivergent and hyperdivergent patients at T1 and T2 that were observed (Table V and VI). Unsurprisingly, at both timepoints the mandibular plane angle and occlusal plane showed statistical significance amongst the groups by nature of the presenting vertical pattern. The greater rotation of the mandible within the hyperdivergent group was also reflected in the skeletal AP cephalometric measurements and in the upright inclination of the upper incisors at T1 and T2. The results also revealed that overjet and overbite measurements in normo/hypodivergent and hyperdivergent groups were not significantly significant at T1. However at T2, the hyperdivergent group had a larger overbite and overjet. The increase in overbite seen in the hyperdivergent group at T2 can be a result of the programmed molar intrusion and routinely prescribed overcorrection planned in the aligner software program. To prevent the mandibular plane from opening in the hyperdivergent group, clinicians may have aimed for more molar intrusion to achieve autorotation of the mandible and ultimately a greater interocclusal relationship. With regards to the overjet, the increase seen in T2 within the hyperdivergent group can be attributed not only to the initial upright presentation of the lower incisors at T1, but due to the greater ability to achieve a larger overjet in hyperdivergent patients who have a less pronounced Class III skeletal relationship. It is also interesting to observe how the upper incisors were more extruded at T1 in the hyperdivergent group in comparison to their normo/hypodivergent counterparts. This dentoalveolar compensation was maintained throughout aligner treatment in hyperdivergent patients as seen in T2.

The present study further revealed that clear aligners are overall, effective at maintaining maxillary incisor inclination when correcting Class III malocclusion in adults. The results did not show statistically significant changes in any maxillary incisor cephalometric variable in the anterior - posterior and vertical dimension. This contrasts to what has been reported in the correction of Class III malocclusion in adults using fixed appliance therapy where maxillary incisors have been shown to procline on average 4.9 degrees.[10] Thus, it can be inferred that patients with an initial presentation of compensated upper incisors would benefit more from clear aligner therapy to maintain upper incisor position and proclination. Increased anterior movement of the maxillary incisors may result in poor aesthetics and prove challenging to achieve an adequate overbite. Alternatively for those individuals who can afford increased proclination of the upper incisors, fixed appliance therapy would be appropriate.

In the same article by Sperry denoting maxillary inclination changes, [10] it was reported that mandibular incisors retroclined by 3.5 degrees when using fixed appliance therapy to correct the Class III malocclusion. The results obtained in this current study of clear aligner therapy showed a slightly greater degree of retroclination of the lower incisors by 5.7 degrees and a retraction of 1.78 mm. It can be reasonably expected in both treatment modalities that a comparable magnitude and degree of lower incisor movement will be seen clinically to achieve orthodontic camouflage.

For further points of discussion, it has been reported in previous studies that clear aligners are good at vertical control by maintaining the molar position. The full occlusal coverage of thermoplastic material across the posterior teeth prevents extrusive molar movements, effectively creating the bite block effect.[3] Paralleling what has been previously reported in past literature, the results of this study reinforce the understanding that clear aligner therapy provides superior vertical control. It is known that adult patients will not exhibit skeletal sagittal correction however mandibular rotation may result in cephalometric measurement changes seen. The conclusions of this research revealed no vertical mandibular plane angle changes thereby negating the idea that the changes noted can be attributed to the rotation of the mandible. The data further expands upon this idea by revealing no statistically significant changes seen in the mandibular plane angle across all vertical patterns (normodivergent, hypodivergent, and hyperdivergent patients). Thus, it is up to the clinician's expertise and acute judgement to plan for additional intrusion mechanics as needed within the clear aligner software. Depending on the clinical presentation of the Class III malocclusion patient, programming intrusion in clear aligners may be advantageous and necessary to achieving a successful treatment outcome.

In contrast to clear aligners, fixed appliance therapy has been reported to extrude teeth. In a study conducted by Nakamura [6], the differences in treatment outcomes caused by TADs versus Class III elastics in Class III malocclusion was studied. The results revealed the tendency for Class III elastics to extrude the upper molars and consequently increase the mandibular plane angle while TADs allowed for mandibular molar intrusion and a counterclockwise movement of the mandible. Provided that molar extrusion is beneficial to increase the vertical dimension of a Class III patient, fixed appliance therapy would be a good treatment modality to deliver. If fixed appliance therapy presents itself to be the main treatment option, auxiliary devices such as TADs can aid in intrusion mechanics to help rotate the mandible and achieve an ideal interarch relationship. However if auxiliary devices are not a familiar part of the clinician's armamentarium and/or successful TAD placement is not achievable, clear aligners may be the preferred and efficacious method of accomplishing treatment objectives.

The limitations of this study are varied. There was no matching control group to serve as an accurate point of comparison. As well, the radiographs involved in this study were 2D lateral cephalograms. Ideally, CBCTs would be preferred across all patients to measure tooth movements and determine anterior-posterior changes in adult Class III malocclusion. Future 3D CBCT superimposition studies will be able to further quantify and assess the amount of mesialization and distalization achieved using clear aligner therapy. Overall due to the paucity of clinical studies concerning both clear aligner therapy and adult Class III correction, continued investigation in this subset of orthodontics is needed to confirm and expand upon the current knowledge and clinical information available.

CONCLUSIONS

The null hypothesis failed to be rejected in all three hypotheses presented.

1) Adult patients with Class III malocclusion treated with clear aligners showed good vertical control with no extrusion of molars during treatment. Thus, it is expected that anterior facial height and initial facial aesthetics will be maintained with clear aligner therapy.
2) There was no difference in the mandibular plane angle changes between normo/hypodivergent patients and hyperdivergent patients treated with clear aligners. This treatment approach is thereby sufficient in maintaining vertical control across all vertical patterns.
3) The correction of the Class III malocclusion in clear aligner therapy was achieved by maintaining the maxillary incisor inclination and retroclining the lower incisors.

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FIGURES AND TABLES

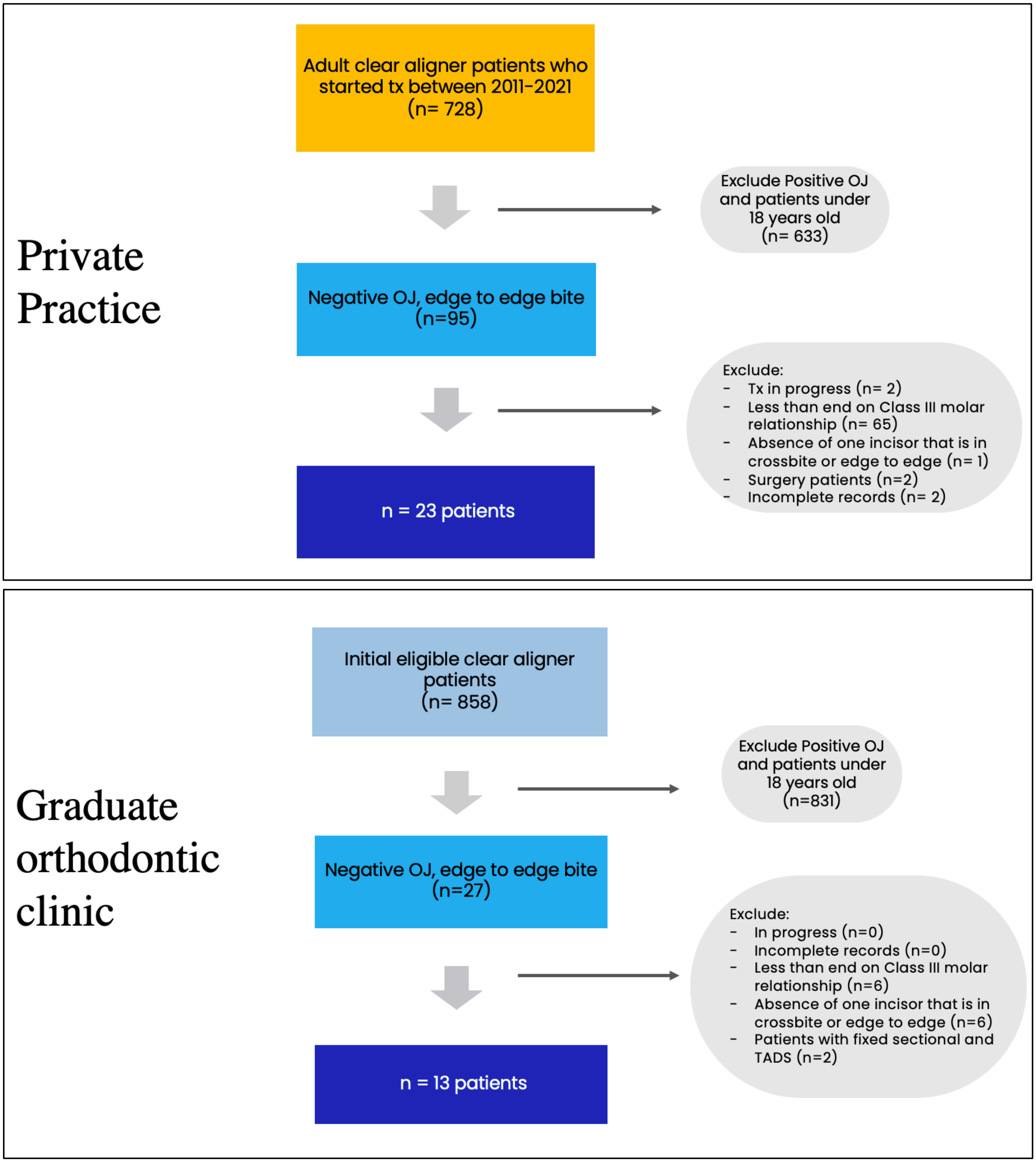
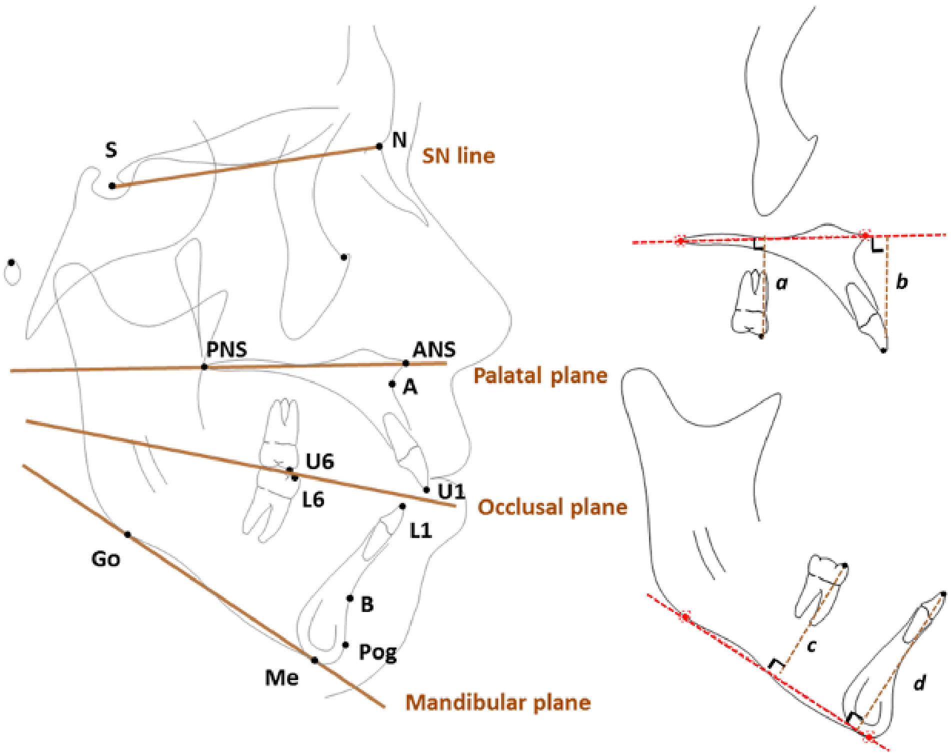


Fig 1. Sampling process for patients in private practice and in graduate orthodontic clinic.



Skeletal AP
- SNA
- SNB
- ANB
- Witts

Skeletal vertical
- Gonial angle
- Mp-SN
- OP-SN
- LFH (mm)
- AFH (mm)

Dental AP
- Interincisal angle
- U1- SN
- U1- NA
- U1- NAd
- L1- NB
- N1- NBd
- IMPA
- OJ

Dental vertical
- OB
- U1 - PP
- U6 -PP
- L1- MP
- L6 - MP

Fig 2. Cephalometric measurements.

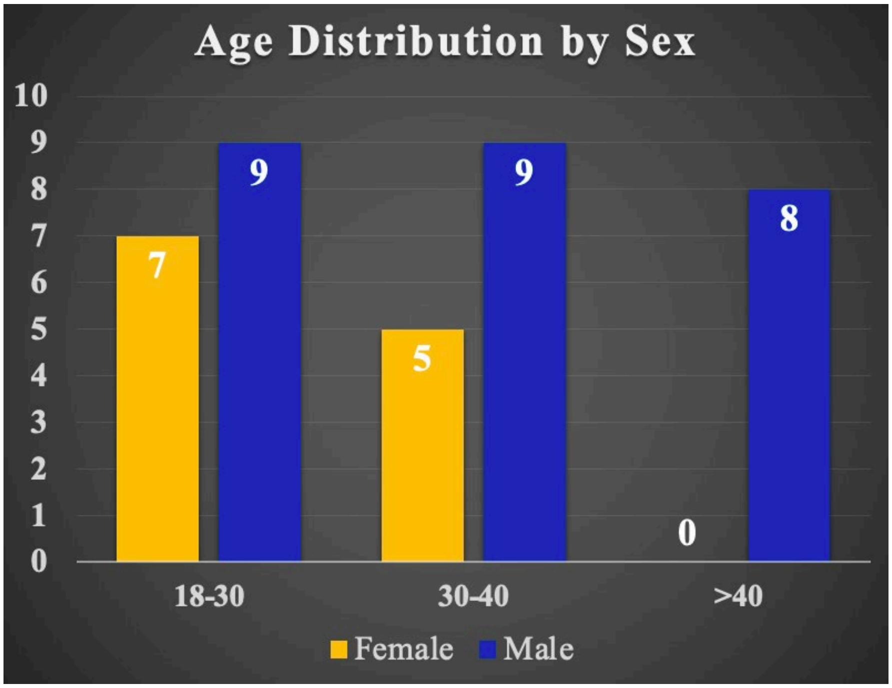


Fig 3. Age distribution by sex.

Table I. Intraclass correlation coefficient

SNA	0.99
SNB	0.99
ANB	0.99
Wits Appraisal (mm)	0.94
Gonial/Jaw Angle (Ar-Go-Me)	1.00
MP - SN	1.00
Occ Plane to SN	0.97
Lower Face Height (ANS-Gn) (mm)	0.99
Anterior Face Height (NaMe) (mm)	1.00
Interincisal Angle (U1-L1)	0.98
U1 - SN	0.98
U1 - NA	0.96
U1 - NA (mm)	0.97
L1 - NB	0.98
L1 - NB (mm)	0.99
IMPA (L1-MP)	0.99
Overjet (mm)	0.99
Overbite (mm)	0.93
U1 - PP (mm)	0.99
U6 - PP (mm)	0.97
L1 - MP (mm)	0.99
L6 - MP (mm)	0.99

Table II. Sample demographics: sex distribution by clinic

	Male		Female		Total	*P* *
	number	%	number	%	number	
Private practice	17	73.9	6	26.9	23	0.21
Graduate clinic	7	53.9	6	46.1	13	

* *P* : Chi-square test

Table III. Cephalometric measurements (skeletal and dental)

	PreTx (T1) (n=36)		PostTx (T2) (n=36)		Changes (T2-T1) (n=36)		*P*
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Age	31.65	7.2	33.72	7.08	2.07	1.12	<.0001
Skeletal AP							
SNA (°)	81.35	4	81.34	4.09	-0.01	0.42	0.875
SNB(°)	80.87	4.42	80.62	4.27	-0.25	0.67	0.0318
ANB (°)	0.48	2.54	0.72	2.43	0.23	0.5	0.0079
Wits (mm)	-4.65	2.56	-3.51	2.66	1.14	1.02	<.0001
Skeletal vertical							
Gonial Ang	125.1	6.26	125.29	6.13	0.19	0.89	0.2076
MP_SN (°)	35.6	6.55	35.88	6.21	0.28	1.19	0.1587
OP_SN (°)	16.11	5.52	15.1	5.27	-1.01	1.36	<.0001
LFH (mm)	74.11	6.39	74.37	6.36	0.26	1.45	0.2862
AFH (mm)	123.94	9.09	124.24	9.02	0.3	1.17	0.138
Dental AP							
IIA (°)	129.67	10.42	135.52	8.85	5.84	7.04	<.0001
U1SN (°)	105.86	8.78	105.52	7.78	-0.34	3.64	0.5817
U1NA (°)	24.51	7.28	24.19	6.72	-0.32	3.63	0.5961
U1NAd (mm)	5.49	2.39	5.62	2.32	0.13	1.23	0.5287
L1NB (°)	25.33	6.48	19.58	6.01	-5.74	4.2	<.0001
L1NBd (mm)	6.11	2.69	4.33	2.52	-1.78	1.29	<.0001
IMPA (°)	88.86	7.41	83.08	6.95	-5.78	4.48	<.0001
OJ (mm)	0.05	1.35	2.5	0.7	1.54	1.2	<.0001
Dental vertical							
OB (mm)	-0.44	1.04	1.1	0.81	2.44	1.4	<.0001
U1_PP (mm)	28.66	3.98	28.84	3.96	0.18	0.56	0.0691
U6_PP (mm)	25.08	2.9	25.06	2.77	-0.02	0.53	0.8043
L1_MP (mm)	42.35	2.97	43.2	2.77	0.85	1.48	0.0015
L6_MP (mm)	34.11	3.14	34.07	3.16	-0.04	0.68	0.7349

Table IV. Hyperdivergency: distribution by sex

	Male		Female		Total	
	n	**%**	**n**	**%**	**n**	***P***
Normo-hypodivergent	16	66.7	4	33	20	0.049
Hyperdivergent	8	33.3	8	67	16	

Table V. Cephalometric measurements at T1 and T2 of normo/hypodivergent groups and hyperdivergent groups

	T1							T2						
	Hypo-Nomodivergent group (n=20)		Hyper-divergent group (n=16)		Differences		*P*	Hypo-Nomodivergent group (n=20)		Hyper-divergent group (n=16)		Differences		*P*
Variable	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD	
Age	32.63	8.69	30.44	4.74	2.19	7.22	0.4	34.47	8.57	32.78	4.72	1.68	7.13	0.5
Skeletal AP														
SNA (°)	82.62	2.87	79.76	4.70	2.86	3.79	0.03	82.58	2.96	79.79	4.84	2.78	3.90	0.04
SNB(°)	83.36	2.74	77.75	4.19	5.61	3.45	<.0001	82.79	2.60	77.68	4.17	5.29	3.38	<.0001
ANB (°)	-0.75	1.84	2.02	2.49	-2.77	2.15	0.001	-0.41	1.68	2.12	2.53	-2.53	2.10	0.001
Wits (mm)	-5.00	1.91	-4.21	3.21	-0.79	2.56	0.4	-3.75	2.02	-3.22	3.35	-0.53	2.69	0.6
Skeletal vertical														
GonAng (°)	123.89	5.27	126.63	7.19	-2.74	6.19	0.2	124.15	5.22	126.72	7.02	-2.57	6.08	0.2
MP_SN (°)	31.19	5.31	41.10	2.50	-9.91	4.30	<.0001	31.61	4.68	41.22	2.73	-9.61	3.94	<.0001
OP_SN (°)	12.58	4.39	20.51	3.07	-7.93	3.86	<.0001	11.66	4.16	19.39	2.74	-7.73	3.60	<.0001
LFH (mm)	72.70	6.58	75.87	5.88	-3.17	6.28	0.1	73.20	6.59	75.84	5.92	-2.64	6.31	0.2
AFH (mm)	123.00	9.16	125.13	9.15	-2.13	9.15	0.5	123.45	9.11	125.23	9.10	-1.79	9.11	0.6
Dental AP														
IIA (°)	128.29	11.04	131.40	9.66	-3.11	10.45	0.4	133.76	9.05	137.72	8.36	-3.96	8.75	0.2
U1SN (°)	110.35	7.56	100.24	6.85	10.12	7.26	0.0002	109.97	6.22	99.96	5.73	10.01	6.01	<.0001
U1NA (°)	27.73	6.99	20.49	5.52	7.24	6.39	0.002	27.41	5.96	20.17	5.41	7.24	5.73	0.001
U1NAd (mm)	6.31	2.10	4.46	2.40	1.85	2.24	0.02	6.48	2.15	4.54	2.12	1.94	2.14	0.011
L1NB (°)	24.72	6.46	26.08	6.64	-1.36	6.54	0.5	19.24	6.05	20.01	6.11	-0.77	6.08	0.7
L1NBd (mm)	5.55	2.18	6.81	3.14	-1.25	2.65	0.2	3.77	2.45	5.04	2.49	-1.27	2.47	0.1
IMPA (°)	90.17	8.07	87.23	6.23	2.94	7.37	0.2	84.65	6.41	81.12	7.31	3.53	6.82	0.1
OJ (mm)	-0.29	1.26	0.48	1.38	-0.77	1.32	0.1	2.25	0.64	2.80	0.68	-0.55	0.66	0.02
Dental vertical														
OB (mm)	-0.25	1.09	-0.69	0.96	0.44	1.03	0.2	0.76	0.61	1.52	0.84	-0.76	0.72	0.003
U1_PP (mm)	27.43	4.23	30.20	3.13	-2.77	3.79	0.04	27.48	4.11	30.54	3.11	-3.07	3.70	0.02
U6_PP (mm)	25.02	3.49	25.15	2.04	-0.13	2.94	0.9	25.05	3.37	25.06	1.86	-0.01	2.81	1.0
L1_MP (mm)	42.49	2.72	42.17	3.35	0.32	3.01	0.8	43.27	2.72	43.11	2.92	0.16	2.81	0.9
L6_MP (mm)	34.43	3.28	33.71	3.01	0.72	3.16	0.5	34.45	3.31	33.60	3.01	0.85	3.18	0.4

Table VI. Cephalometric changes comparing the differences between normo/hypodivergent and hyperdivergent groups

	Changes (T2-T1)						
	Hypo-Nomodivergent group (n=20)		Hyper-divergent group (n=16)		Differences		*P*
Variable	Mean	SD	Mean	SD	Mean	SD	
Age	1.85	0.94	2.35	1.29	-0.50	1.11	0.19
Skeletal AP							
SNA (°)	-0.04	0.38	0.03	0.47	-0.08	0.43	0.60
SNB(°)	-0.39	0.76	-0.07	0.5	-0.32	0.66	0.16
ANB (°)	0.34	0.54	0.1	0.42	0.24	0.49	0.15
Wits (mm)	1.26	1.16	0.99	0.83	0.26	1.03	0.45
Skeletal vertical							
GonAng (°)	0.27	1.12	0.1	0.5	0.17	0.90	0.58
MP_SN (°)	0.42	1.34	0.12	0.98	0.30	1.19	0.45
OP_SN (°)	-0.92	1.34	-1.12	1.42	0.20	1.38	0.67
LFH (mm)	0.5	1.72	-0.03	1.02	0.53	1.45	0.28
AFH (mm)	0.45	1.4	0.11	0.82	0.34	1.18	0.40
Dental AP							
IIA (°)	5.47	5.45	6.31	8.82	-0.85	7.13	0.73
U1SN (°)	-0.38	3.08	-0.28	4.35	-0.10	3.69	0.94
U1NA (°)	-0.33	3.11	-0.32	4.3	0.00	3.68	1.00
U1NAd (mm)	0.17	1.06	0.08	1.45	0.08	1.25	0.84
L1NB (°)	-5.48	3.38	-6.08	5.14	0.60	4.25	0.68
L1NBd (mm)	-1.79	0.87	-1.77	1.71	-0.02	1.31	0.97
IMPA (°)	-5.51	3.98	-6.11	5.15	0.60	4.53	0.70
OJ (mm)	2.54	1.56	2.32	1.2	0.23	1.41	0.63
Dental vertical							
OB (mm)	1.01	1.07	2.21	1.04	-1.20	1.05	0.0018
U1 PP (mm)	0.05	0.48	0.34	0.64	-0.30	0.55	0.12
U6_PP (mm)	0.03	0.48	-0.09	0.61	0.12	0.54	0.50
L1_MP (mm)	0.78	1.67	0.94	1.25	-0.16	1.50	0.76
L6_MP (mm)	0.02	0.83	-0.11	0.46	0.13	0.69	0.57