

# Self-ligating *versus* Invisalign: analysis of dento-alveolar effects

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## Summary

**Self-ligating *versus* Invisalign: analysis of dento-alveolar effects.**

**Aim.** *The aim of this study was to evaluate the changes in the transverse dimension and the perimeter of the maxillary arch produced by low friction self-ligating brackets TIME 3 compared to the Invisalign technique. Materials and methods. Both the self-ligating sample and the Invisalign group were composed of 20 subjects, evaluated at the beginning (T0) and at the completion of therapy (T1). All subjects presented a Class I malocclusion with mild crowding in a permanent dentition, without craniofacial anomalies, missing teeth or a history of orthodontic treatment. Dento-alveolar measurements were made on the maxillary dental casts at T0 and T1. Significant differences between the treated groups were assessed with Independent Samples t test ( $p < 0.05$ ).*

**Results.** *Statistically significant differences between self-ligating sample and Invisalign group were recorded for CWC, FPWF, FPWL, SPWF, SPWL, and AP measurements. No significant changes were found for CWL, MWF, MWL, and AD values. There was not a statistically significant difference between the treatment durations of the groups: 1.8 years for both patients. These data suggest that Invisalign treatment cannot be somewhat faster than fixed appliances. Moreover the final occlusion might not be as ideal.*

**Conclusions.** *The low friction self-ligating system produced statistically significant different outcomes in the transverse dento-alveolar width and the perimeter of the maxillary arch during treatment when compared to Invisalign technique.*

**Key words:** self-ligating, crowding, Invisalign.

## Introduction

The Invisalign system (Align Technology, Santa Clara, Ca, USA) an esthetic orthodontic treatment with removable, clear semielastic polyurethane aligners has become more often a common treatment choice since its first appearance in 1997. This computer-aided modeling technique can fabricate numerous aligners to move teeth with relative precision to obtain a good occlusion. These aligners are made from a thin, transparent plastic that fits over the buccal, lingual/palatal and occlusal surfaces of the teeth. They conventionally are worn for a minimum of 20 hours per day and are changed sequentially every two weeks. Invisalign has been indicated by its manufacturer to be used in adults and adolescents who have fully erupted permanent dentitions (1,2).

Align Technology provides guidelines for the types of malocclusion that can be successfully treated with Invisalign. Cases for which Invisalign is indicated include mild to moderate crowding (1-6 mm), mild to moderate spacing (1-6 mm), nonskeletal constricted arches, and relapse after fixed appliance therapy (3). The manufacturer claims that Invisalign can effectively perform the following orthodontic movements: space closure, alignment after interproximal reduction, dental expansion, flaring, and distalization (4). The Invisalign system has become a popular treatment choice for clinicians because of the esthetics and comfort of the removable clear aligners compared with traditional appliances.

One of the more commonly encountered types of patients who request Invisalign treatment are those who have previously received orthodontic treatment using fixed appliances and do not want fixed appliances for their present orthodontic treatment. Esthetic concerns during follow-up orthodontic treatment may be a significant factor, with many patients not wanting to show metal or partially clear fixed appliances with arch wires when they smile. Another group of patients who want Invisalign are teenagers who wish to improve their esthetics, but are not interested in having the appearance of fixed appliances (5).

To this date, little clinical research has been published to comprehensively study the effectiveness of Invisalign treatment (1-3). The lack of such objective information on this product has made it difficult for clinicians to objectively characterize the efficacy of Invisalign as compared to fixed appliances.

In the last 20 years self-ligating brackets have undergone a renaissance because the concept of self-ligation having been pioneered in 1930s. Self-ligating brackets have a built-mechanism to close off the edgewise slot, obviating the need for elastomerics or steel ties to secure the archwire in the bracket slot. The chief advantages of self-ligating system over conventional appliances are claimed to include reduced friction, more robust ligation, more efficient tooth movement and sliding mechanics that can reduce treatment time (6,7).

The aim of the present investigation was to compare the dento-alveolar effects of the Invisalign system and of self-ligating multibrackets treatment in particular relatively to transverse dimension, arch perimeter and arch depth on maxillary jaw.

### Subjects and methods

A sample of 40 Caucasian subjects (19 males, 21 females) who sought for orthodontic treatment was selected consecutively at the Department of Orthodontics "Tor Vergata", Dental school, University of Rome. The inclusion criteria for the enrollment in the study group were Class I malocclusion, mild crowding in mandibular arch (mean crowding  $4.4 \pm 0.8$  mm), permanent dentition, vertebral maturation as assessed on lateral cephalograms more advanced than CS4 (postpubertal) (8) and no previous orthodontic treatment. All subjects were divided into two groups according to the following treatment protocols:

1. the self-ligating group comprised 20 subjects (9 female, 11 males) who were treated consecutively with self-ligating brackets Time 3 at the Department of Orthodontics of the University of Rome "Tor Vergata";
2. the invisalign group included 20 subjects (12 female, 8 males) who were treated consecutively with a series of invisible removable aligners at the Department of Orthodontics, University of Rome "Tor Vergata".

These subjects were instructed to wear each aligner 22 hours a day, 7 days a week for 2 to 3 weeks. All patients were asked to complete a daily compliance log during treatment, recording the number of hours the aligners were worn each day (9).

Success of the therapy at the end of the observation period was not a determinant factor for selection of patients. Pretreatment records consisted of initial dental casts, orthopantomography, and lateral cephalograms (T1); for each patient the same records were taken immediately after treatment to avoid any relapse (T2).

The average age of the self-ligating group was 15 years 6 months at T1. The mean age of the invisalign group was 18 years 4 months at T1. Mean duration of treatment was 18 months  $\pm$  3 months in the self-ligating group and 18 months  $\pm$  2 months in the invisalign group.

The treatments protocols comprised:

1. preadjusted self ligating brackets Time 3 (AO American Orthodontics Products), superelastic nickel titanium archwires (.014-in followed by .016-in and .016x.022-in) of Form I – Force I (AO American Orthodontics), and stainless steel archwire .017x.025-in (AO American Orthodontics),
2. a series of nearly invisible appliances, Invisalign (Align Technology, Santa Clara, Calif.), to incrementally move the teeth from their crowded initial position to their final straightened position. The anterior teeth were reduced at each interproximal location by means of diamond-coated finishing strips used for interproximal reduction.

The following measurements were made on the maxillary dental casts at T1 and T2 (10):

- intercanine width (lingual): distance between the most lingual points on the lingual surface of the maxillary canines;
- intercanine width (cusp): distance between the tips of the cusps of the maxillary canines;

- first interpremolar width (lingual): distance between the most lingual point on the lingual surface of the maxillary first premolars;
- first interpremolar width (fossa): distance between the central fossae on the occlusal surface of the maxillary first premolars;
- second interpremolar width (lingual): distance between the most lingual point on the lingual surface of the maxillary second premolars;
- second interpremolar width (fossa): distance between the central fossae on the occlusal surface of the maxillary second premolars;
- intermolar width (lingual): distance between the lingual fissure locations on the lingual surface of the maxillary first molars;
- intermolar width (fossa): distance between the mesial fossae on the occlusal surface of the maxillary first molars;
- arch depth: distance from a point midway between the facial surfaces of the central incisors to a line tangent to the mesial surfaces of the first permanent molars;
- arch perimeter: sum of the segments between contact points from the mesial surface of the first permanent molar to the mesial surface of the opposite first permanent molar.

### Statistical analysis

All measurements were made by 1 operator (C.P.) and repeated a month later. Casual and systematic errors were calculated comparing the first and the second measurements with paired t-test and Dahlberg's formula. Descriptive statistics were calculated for all maxillary dental cast measurements at T1 and T2, and for the T2-T1 changes. The Independent Sample T tests were used to analyze statistical differences between T1 and T2 values. The level of significance was set at  $P < 0.05$

A control group is not required when investigating dento-alveolar changes during a short observation period as described in the present study (18 months). Transverse and sagittal arch changes in untreated subjects in the permanent dentition at an average age of 15 years 6 months are expected to be minimal.

### Results

No systematic error for any measures were found. Random error ranged from 0.2 to 0.4 mm. Descriptive statistics are reported in Tables.

In the self-ligating group intercanine width (cusp) showed significant increase from T1 to T2: 3.15 mm. The first interpremolar widths (lingual and cusp) had significant increases of 3.40 mm and 2.45 mm, respectively, similar to the second interpremolar widths (lingual and cusp), with significant increases of 2.50 mm and 2.15 mm, respectively (Tab. 1).

The invisalign group showed statistically significant increase in second interpremolar width at the fossa point (0.45 mm) and in intermolar widths at the fossa (0.50 mm) (Tab. 2). Significant difference was found between the 2 groups for the intercanine widths, the change at the cusp was significantly larger in the self-ligating group (2.65 mm) (Table 3).

Table 1 - Descriptive statistics and comparison of maxillary measurements at T1 and T2 in self-ligating group.

SELF-LIGATING							
Value	Mean	S.D.	Value	Mean	S.D.	Difference	S.D.
<b>CWC0</b>	33.80	2.59	<b>CWC1</b>	36.95	1.82	3.15	2.30
<b>CWL0</b>	24.70	2.41	<b>CWL1</b>	25.50	1.93	0.80	1.67
<b>FPWF0</b>	34.50	2.69	<b>FPWF1</b>	37.90	1.59	3.40	1.96
<b>FPWL0</b>	26.85	2.60	<b>FPWL1</b>	29.30	2.20	2.45	2.01
<b>SPWF0</b>	39.85	2.68	<b>SPWF1</b>	42.35	1.79	2.50	2.16
<b>SPWL0</b>	31.35	2.16	<b>SPWL1</b>	33.50	1.76	2.15	2.03
<b>MWFO</b>	45.35	2.70	<b>MWF1</b>	46.25	2.34	0.90	2.45
<b>MWLO</b>	36.60	2.66	<b>MWL1</b>	36.90	2.51	0.30	2.15
<b>APO</b>	75.15	3.17	<b>AP1</b>	76.45	3.03	1.30	2.23
<b>ADO</b>	31.15	11.67	<b>AD1</b>	29.25	1.83	1.90	11.40

Table 2 - Descriptive statistics and comparison of maxillary measurements at T1 and T2 in Invisalign group.

INVISALIGN							
Value	Mean	S.D.	Value	Mean	S.D.	Difference	S.D.
<b>CWC0</b>	33.75	2.67	<b>CWC1</b>	34.25	2.27	0.50	1.10
<b>CWL0</b>	23.15	2.21	<b>CWL1</b>	23.20	1.82	0.05	.69
<b>FPWF0</b>	35.25	2.59	<b>FPWF1</b>	35.30	2.49	0.05	.51
<b>FPWL0</b>	25.20	2.48	<b>FPWL1</b>	25.35	2.08	0.15	.59
<b>SPWF0</b>	40.10	2.59	<b>SPWF1</b>	40.55	2.42	0.45	.51
<b>SPWL0</b>	30.30	2.90	<b>SPWL1</b>	30.60	2.44	0.30	.80
<b>MWFO</b>	46.20	3.07	<b>MWF1</b>	46.70	2.92	0.50	.51
<b>MWLO</b>	34.00	2.81	<b>MWL1</b>	34.05	2.72	0.05	.51
<b>APO</b>	73.65	4.20	<b>AP1</b>	73.60	3.89	-0.05	1.61
<b>ADO</b>	26.85	1.69	<b>AD1</b>	26.85	1.98	0.00	1.17

The comparison between two groups of the first inter-premolar measurements showed an improvement in the self-ligating subjects significantly bigger at the lingual point (2.30 mm), and at the cusp (3.35 mm), similar to the second interpremolar widths (lingual and cusp), with significant increase of 1.85 mm and 2.05 mm, respectively.

### Discussion

There was not a statistically significant difference between the ages of the Invisalign and braces groups. The mean age in the Invisalign group was greater than that in the braces group by almost 3 years. This discrepancy was expected because young adults are more likely to be interested in treatment with greater esthetics and comfort. However, tooth movement should be similar regardless of age with all other things being equal, such as periodontal condition and patient compliance. Fixed appliances should have an advantage because of the ability to make precise wire adjustments within 0.5 mm to intrude or extrude teeth as necessary; it has been

thought that removable aligners cannot be this accurate. Fixed appliances produced better treatment outcomes than Invisalign in orthodontist's hands, given his level of expertise. Particularly important to the outcome of Invisalign is proficiency in using Align Technology's Clincheck program that allows the practitioner to accept or modify the treatment plan of tooth movements before the aligners are actually fabricated (11).

Interestingly, there was not a statistically significant difference between the treatment durations of the groups: 1.8 years for both patients. These data suggest that Invisalign treatment cannot be somewhat faster than fixed appliances. Moreover the final occlusion might not be as ideal (12).

Arch form development and posterior expansion of the dental arches have been indicated as effects of low-friction mechanics with self-ligating brackets during the initial phases of treatment with superelastic nickel-titanium .014-in wires (13). Our findings showed statistically more significant increases in maxillary arch perimeter with low-friction brackets than invisalign during treatment. No differences were found in maxillary arch depth between two

Table 3 - Descriptive statistics and comparison between two groups.

	SELF-LIGATING		INVISALIGN		INDEPENDENT SAMPLE T TEST	
	Difference	S.D.	Difference	S.D.	MEANS	P value
<b>CWCDD</b>	3.15	2.30	0.50	1.10	2.65*	.000
<b>CWLDD</b>	0.80	1.67	0.05	.69	0.75	.071
<b>FPWFDD</b>	3.40	1.96	0.05	.51	3.35*	.000
<b>FPWLDD</b>	2.45	2.01	0.15	.59	2.30*	.000
<b>SPWFDD</b>	2.50	2.16	0.45	.51	2.05*	.000
<b>SPWLDD</b>	2.15	2.03	0.30	.80	1.85*	.001
<b>MWFDD</b>	0.90	2.45	0.50	.51	0.40	.479
<b>MWLDD</b>	0.30	2.15	0.05	.51	0.25	.617
<b>APDD</b>	1.30	2.23	-0.05	1.61	1.35*	.034
<b>ADDD</b>	1.90	11.40	0.00	1.17	1.90	.463

\* P&lt;0.05

groups. Statistically significant increases were found for all width measurements between the lateral and posterior teeth, with the exception of the first molars measured lingually only in braces group.

Increases in arch width that used lingual points for measurement were consistently smaller than the increases recorded by using points located at cusps or occlusal fossae.

The self-ligating system consent a significant increase in Inter canine widths (cusp) during treatment (3.15 mm), whereas the measurements at the lingual point was not statistically significant. The first interpremolar widths (lingual and cusp) had significant increases, while the changes in intermolar width at the lingual point and at the fossa were not statistically significant (0.90 mm and 0.30 mm, respectively). The arch dept and arch perimeter had not a statistically significant T2-T1 increase (1.30 mm and 1.90 mm).

This indicates that expansion of the maxillary arch in self-ligating group was achieved with a component of buccal inclination of canines and posterior teeth (14).

The greatest transverse increases were recorded at the level of the premolars and the canines, whereas smaller increases were found at the level of the molars. A possible reason for this differential effect might be the shape of the archwires used for alignment of the maxillary teeth (Tru-Arch form); these have an accentuated width in the canine first premolar region (15).

The significant increases in the transverse widths of the maxillary arch led to a statistically significant increase in

maxillary arch perimeter (on average 3.5 mm), a clinically favorable result for nonextraction treatments.

The invisalign group showed not statistically significant changes in intercanine widths (lingual and cusp), and in the first interpremolar widths (lingual and cusp). The change in the second intermolar width at the lingual point was not statistically significant (0.30 mm).

A significant change in intermolar widths at the fossa was found (0.50 mm), while the measurement at lingual point was not significant (0.05 mm). The arch dept and arch perimeter had not a statistically significant T2-T1 increase (-0.05 mm and 0.00 mm).

No significant differences were found between the 2 groups for the intercanine widths at lingual point (0.75 mm), whereas the change at the cusp was significantly larger in the self-ligating group (2.65 mm).

The changes in arch dept and arch perimeter were not significantly different from T1 to T2.

In invisalign subjects there was not expansion in maxillary arch in all measurements considered.

Interproximal reduction was performed as prescribed, but no other modifications were made to augment tooth movement (16). Therefore, the pass rate for Invisalign cases might be higher if more sophisticated techniques, such as auxiliaries, interarch elastics, or combination treatment with braces had been used. On the other hand, the braces patients were treated with tip-edge fixed appliances, which can make fine adjustments with uprighting springs, rotation springs, interarch elastics, and other auxiliaries in addition to the tooth movements made possible by the



bracket prescription (17).

However, there are several reasons that Invisalign might not be as effective as fixed appliances. Primary among them is compliance. Because the aligners are removable, the orthodontist must rely on the patient's motivation and dependability to achieve the desired results. The removability of Invisalign is an advantage to the patient but not to the clinician. Another reason that Invisalign fails to compare with braces is that Invisalign minimally addresses the occlusion (18). Boyd et al. (16) admitted that, when evaluating the occlusal outcome of an Invisalign case, it was evident that the same or an even better result could have been achieved with conventional braces in arguably less time.

Therefore, the major advantages of Invisalign over braces are that the aligners are esthetic, removable, and comfortable, but there are no biomechanical advantages.

### Conclusions

- Self-ligating multibrackets treatment resulted effective to solve mild crowding by increasing arch width and correcting buccolingual inclination, occlusal contacts and root angulations.
- Invisalign treatment has also had success with straightening arches by derotating teeth and by leveling arches.
- Invisalign can easily tip crowns but cannot tip roots because of lack of control of tooth movement.
- No statistically significant differences between the two groups are evident when malocclusions start relatively well aligned roots.

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