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Presurgical Decompensation in Patients Affected by Class III Dentoskeletal Malocclusion: A Comparison between Two Different Bracket Systems

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Abstract: The aim of this study was to analyse if bracket systems could affect the incisors' decompensation in a group of patients affected by dentoskeletal Class III malocclusion and on the duration of presurgical orthodontics. A single-centre retrospective study was carried out on two groups of patients affected by dentoskeletal Class III and who underwent orthognathic surgery. Group 1, comprising 25 subjects (13 males, 12 females; mean age, 27.4 y.o.), was treated with interactive self-ligating brackets; group 2, comprising 10 subjects (5 males, 5 females; mean age, 27.2 y.o.), was treated with conventional twin brackets. Bracket prescription and archwire sequence were the same for both groups. Data were collected about age, upper incisors' axis (UI^ANS-PNS), lower incisors' axis (IMPA), and the total duration of presurgical orthodontics and were then compared between the two groups. The variation in the upper incisor axis and the duration of presurgical orthodontics was not significant between the groups, while the difference in the IMPA was small but significant. The use of a self-ligating bracket did not influence the decompensation of the upper incisors or the duration of presurgical orthodontics when compared with conventional ligating brackets. The difference in the IMPA was significantly different but clinically negligible.

Keywords: Class III malocclusion; dentoskeletal malocclusion; orthognathic surgery; presurgical orthodontics; self-ligating brackets

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1. Introduction

"Self-ligating brackets" (SLBs) are bracket systems widely used in current clinical practice. They are manufactured with an integrated closing mechanism (spring, clip, slide system, etc.) that holds the orthodontic wire into the slot, thus eliminating the need for metal or elastomeric ligatures. As the wire is not forced into the slot with ligatures, it slides into the entire inter-arch system of brackets during orthodontic movement; therefore, the frictional resistance to the archwire sliding is reduced. Compared with conventional ligating brackets, the lower friction between the wire and bracket may result in lower resistance to orthodontic movements [1].

However, differences between self-ligating and conventional ligating brackets (CLBs), in particular the better orthodontic efficiency and the shorter treatment time of self-ligating brackets compared with conventional brackets, have been greatly debated in recent years, and the present studies have not yet been conclusive [2].

Many systematic reviews have analysed the features of SLBs and CLBs over time: Many of them have not reported significant differences between the two bracket systems in expanding transversal dimensions, space closure, torque expression, or orthodontic efficiency to correct crowding or level of the arch. These studies have reported insufficient evidence to demonstrate the clear clinical superiority of a bracket system over the other, suggesting the need to perform further studies with high methodological quality [3–5].

Over the years, clinical reports have demonstrated that treatment time is not reduced in patients treated with self-ligating brackets, despite the reduced frictional resistance to archwire sliding [6–8]. Pandis et al. reported that self-ligating brackets had 2.7 × faster correction when moderate crowding is present (an Irregularity Index of less than 5), while the difference was not significant in highly crowded arches (Irregularity Index higher than 5), and the treatment time was increased by additional 20% for each Irregularity Index value [9]. Songra et al. reported that the time to initial alignment was significantly shorter for conventional brackets than for either active or passive self-ligating brackets, and there was no statistically significant difference in passive, active, or total space-closure times among the three brackets investigated [10].

On the other hand, Jahanbin et al. reported that dental irregularity significantly improved with SLBs, and Bashir et al. found that self-ligating brackets had a higher increase in inter-molar width than conventional brackets [11,12].

The systematic review of Yang et al. showed that SLBs are not clinically superior to CLBs in expanding transversal dimensions and in space closure [13]. Shahba et al. reported that the type of SLBs, either active or passive, does not affect the rate or type of movement during canine retraction in extraction cases, and the anchorage loss of the upper molars was nearly the same in both types [14].

With regard to torque expression, Al-Thomali et al. demonstrated that CLBs present the highest torque expression compared with SLBs. Minor differences were recorded in the torque expression of active and passive self-ligating brackets [15].

Among the many areas that require further investigation, the comparison of bracket systems in patients affected by dentoskeletal malocclusion is of particular interest. A dentoskeletal malocclusion is typically characterised by dental compensations as a consequence of the compensatory adaptation of teeth to the skeletal and functional growth discrepancy; for example, in Class III malocclusion, the lower incisors retroclinate, and the upper incisors proclinate, as a consequence of altered sagittal growth. The correction of such malocclusions requires presurgical orthodontic preparation before orthognathic surgery to eliminate occlusal compensations, therefore unmasking the real maxillomandibular skeletal discrepancy and achieving as stable postoperative occlusion as possible [16–18].

In these patients, the neuromuscular imbalance of the initial malocclusion may hinder and even interfere with presurgical orthodontic decompensation movements since the orthodontic forces act against the neuromuscular forces and go in the opposite direction to the natural dentoalveolar compensation, affecting the performance of the entire bracket system [19]. Although self-ligating brackets are widely adopted in orthodontic practice, to date, only two papers have reported the use of self-ligating appliances in presurgical orthodontics [20,21].

The purpose of this research was to report the experience of our unit in the use of self-ligating brackets in presurgical orthodontics; to test if there were differences between a particular type of interactive self-ligating bracket and conventional twin brackets in a group of patients suffering from dentoskeletal Class III malocclusion who underwent orthognathic surgery. The variables we analysed were the axes of the upper and lower incisors following the treatment of decompensation and the time needed to complete the entire presurgical preparation. The null hypothesis (H0) was that there were no significant differences between the two groups in the correction of the axes of the upper and lower incisors or in the time needed to complete the presurgical preparation.

2. Materials and Methods

The sample for the study was chosen from the population of patients affected by dentoskeletal Class III malocclusion in our Unit of Orthodontics, in the period between 2016 and 2020, and treated with combined orthodontic–surgical therapy after undergoing presurgical orthodontic preparation. In this study, we included a group of subjects (G1) treated with interactive self-ligating brackets (Empower, American Orthodontics, Sheboygan, WI, USA) and a second group (G2) comprising patients treated with conventional straight wire brackets (3M Company, Saint Paul, MN, USA), all with MBT prescription and 0.022 × 0.028 in. slot until second molars on both arches. All the selected patients were treated with the same archwire sequence: 0.014 in, 0.018 in., 0.014 × 0.025 in., and 0.018 × 0.025 in. copper–nickel–titanium archwires and 0.019 × 0.025 in. stainless steel archwires.

From an initial population of 105 patients, in this study, we further selected only patients whose crowding was slight or moderate (measured with Little's Irregularity Index less than 3) and did not require extractions.

Patients affected by other skeletal malocclusions or syndromic, as well as those treated with other prescriptions, other bracket systems, and Surgery First protocol, were excluded. Patients who had undergone orthodontic treatment only or incomplete treatments, as well as patients who were still in therapy, were also excluded.

The variables collected and analysed to evaluate the differences between the groups were the axes of the upper and lower incisors after the presurgical decompensation and the time taken to complete the presurgical orthodontic preparation in both groups, calculated in months.

The axis of the incisor is an important cephalometric parameter in presurgical orthodontics for determining if a patient is "ready for surgery". Therefore, a single operator measured the angle between the axis of the upper incisor and the palatal plane (U1ˆANS-PNS, n.v. males: 112.1° SD 5.7, females: 111.1 SD 6.2) and the angle between the axis of the lower incisor and the mandibular plane (L1ˆGo-Gn, or IMPA, n.v. males: 95.3° SD 6.6; females: 92.1° SD 9.0) on the pretreatment (T0) and presurgical (T1) lateral cephalograms in both groups. The means for both angles were compared at T0 and T1. The mean variations in both angles between T1 and T0 were calculated and compared as well.

Moreover, the pretreatment ANB angle was measured at the start of the treatment and compared between the groups to evaluate whether the mean value of the skeletal class was similar in the two groups.

Statistical Analysis

The collected data were first analysed with descriptive statistics. One operator (A.M.) performed all the measurements; the same operator repeated the measurements after five months on ten subjects in each group in random order. Another Author (R.G.) repeated the cephalometric analysis for the assessment of the inter-rater reliability. The Dahlberg formula was used to evaluate the intra- and inter-rater reliability.

About the comparison between the groups, the normality of the distribution was verified with the Shapiro–Wilk test. On the basis of the normality, the comparison results of the U1ˆANS-PNS were analysed with Student's parametric *t*-test for independent samples, while the variation in the IMPA was determined with the nonparametric Wilcoxon signed-rank test.

A p-value < 0.05 was considered statistically significant. Statistical analysis was performed with the R software (version 4.2.0; https://www.r-project.org/, accessed on 27 May 2022). The protocol was approved by our Department and by the local University Ethical Board, prot. n. 4632.

3. Results

The demographic characteristics of the groups involved in this study are displayed in Tables 1 and 2, respectively. G1 comprised 25 subjects, 13 males and 12 females; the mean age of the group was 27.4 y.o. (SD 3.71). G2 comprised 10 subjects, 5 males and 5 females, with a mean age of 27.2 y.o. (SD 4.2).

Table 1. Descriptive statistics of G1. ANB T0: skeletal class at the start of the therapy. U1^ANS-PNS: the angle between the axis of the upper incisor and the palatal plane, at the start (T0) and end of the presurgical orthodontics (T1). IMPA: the angle between the axis of the lower incisor and the mandibular plane, at the start (T0) and end of the presurgical orthodontics (T1).

Patient	Age	ANB T0	U1^ANS-PNS T0	U1^ANS-PNS T1	IMPA T0	IMPA T1	Time Needed for Presurgical Orthodontics
Mean	27.40	−1.88	118.04	111.28	83.64	86.96	24.88
S.D.	3.71	1.42	3.46	2.82	4.55	4.15	6.28
Std. Error	0.74	0.28	0.69	0.56	0.91	0.83	1.26
Lower 95	25.95	−2.44	116.68	110.17	81.85	85.33	22.42
Upper 95	28.85	−1.32	119.40	112.39	85.43	88.59	27.34
Min	21.00	−4.00	112.00	106.00	75.00	80.00	14.00
Max	35.00	0.00	127.00	116.00	91.00	94.00	36.00

Table 2. Descriptive statistics of G2. U1^ANS-PNS: the angle between the axis of the upper incisor and the palatal plane, at the start (T0) and end of the presurgical orthodontics (T1). IMPA: the angle between the axis of the lower incisor and the mandibular plane, at the start (T0) and end of the presurgical orthodontics (T1).

Patient	Age	ANB T0	U1^ANS-PNS T0	U1^ANS-PNS T1	IMPA T0	IMPA T1	Time Needed for Presurgical Orthodontics
Mean	27.20	−2.10	117.60	110.90	84.20	88.30	22.90
S.D.	4.24	1.52	3.24	2.47	4.21	3.62	8.45
Std. Error	1.34	0.48	1.02	0.78	1.33	1.15	2.67
Lower 95	24.57	−3.04	115.59	109.37	81.59	86.05	17.66
Upper 95	29.83	−1.16	119.61	112.43	86.81	90.55	28.14
Min	21.00	−4.00	112.00	105.00	78.00	83.00	11.00
Max	33.00	0.00	122.00	113.00	90.00	93.00	36.00

The results of the Dahlberg formula for intra-rater repeatability were found between 1.42° for the IMPA and 3.71° for U1^ANS-PNS. The results of inter-rater reliability were found between 2.19° for the IMPA and 4.92° for U1^ANS_PNS. Therefore, the intra-rater repeatability was excellent and the inter-rater repeatability was good, especially for the measure of the IMPA angle.

At the start of the treatment (T0), the mean ANB angle of G1 was −1.88° (SD 1.42), while the mean ANB angle of G2 was −2.10 (SD 1.52). The difference in the means was not statistically significant (p = 0.668).

The axis of the upper incisor was increased in both groups, compared with normal values (G1: mean 118.0° SD 3.46; G2: mean 117.6 SD 3.24); therefore, the upper incisors were proclined at T0. The IMPA angle at T0 was decreased in both groups (G1: mean 83.6° SD 4.55; G2: mean 84.2°, SD 4.2) with the retroclination of the lower incisors, as a result of the dental compensation. The comparison between the groups at T0 did not show statistically significant differences, for the upper incisor angle (p = 0.6852) or the IMPA (p = 0.7326).

At the end of the presurgical orthodontics (T1), the mean value of the axis of the upper incisor was 111.3° SD 2.82 for G1 and 110.9° SD 2.47 for G2. The mean presurgical value returned within normal values in both groups. In T1, the mean IMPA angle of G1 was 86.9° SD 4.15, while the mean value of e G2 was 88.3° SD 3.62; in both groups, the mean value returned to normal ranges. The difference in the means at T1 after the presurgical preparation, for the upper ($p = 0.798$) and lower incisors' axes ($p = 0.798$), was not statistically significant.

The mean variations in the upper and lower incisors' axes were calculated for both groups and are shown in Table 3, while the inferential statistics are presented in Table 4. In both groups, the value of the upper incisors' axis in T1 decreased, with a mean difference of 7.0° in group 1 and 6.7° in group 2, and the comparison did not show significant differences ($p = 0.6852$). The presurgical value of the IMPA increased in both groups, as a result of the lower incisors' proclination, with a mean difference of 3.1° in G1 and 4.1° in G2; this difference was significant ($p = 0.0278$).

Table 3. Calculation of the differences between the values of T1 and T0 for each group of the study.

	Difference U1^ANS-PNS		Difference IMPA	
Patient	**G1**	**G2**	**G1**	**G2**
Mean	−6.64	−6.70	3.20	4.10
S.D.	2.90	1.95	1.12	0.88
Std. Error	0.58	0.62	0.22	0.28
Lower 95	−7.78	−7.91	2.76	3.56
Upper 95	−5.50	−5.49	3.64	4.64
Min	−13.00	−10.00	2.00	3.00
Max	−3.00	−4.00	5.00	5.00

Table 4. Inferential analysis of the differences between the groups. * = statistical significance.

Comparison G1 vs. G2	Analysis	t	V	W	*p*-Value	Significance
ANB T0	Wilcoxon rank-sum test			136.8	0.668	
U1^ANS-PNS T0	*t*-test	0.35605			0.726	
IMPA T0	*t*-test	−0.3471			0.7326	
U1^ANS-PNS T1	Wilcoxon signed-rank test		137.5		0.6419	
IMPA T1	Wilcoxon signed-rank test		98.5		1.3302	
Difference U1^ANS-PNS	Wilcoxon signed-rank test		136		0.6852	
Difference IMPA	Wilcoxon signed-rank test		67		0.0278	*
Duration	*t*-test	0.7625			0.4512	

The mean time to perform the entire presurgical orthodontic preparation was 25.9 months in G1 and 22.9 months in G2. The difference in the mean duration of the presurgical therapy between G1 and G2 was not statistically significant ($p = 0.4512$).

4. Discussion

Among the objectives to achieve with presurgical orthodontics, the alignment, levelling, and resolution of crowding are pivotal in the first phases of the presurgical treatment. Another key objective is the correction of dental compensation. In particular, the compensatory axial inclination of the incisors in Class III patients may often mask the real extent of the occlusal discrepancy in relation to the skeletal one and could interfere with the optimal surgical repositioning of the jaws.

From a surgical point of view, the maxillomandibular repositioning in the sagittal plane is greatly influenced by the orthodontic correction of the incisors' axial inclination.

Only when the physiologic and proportional relationship between the incisors and their own skeletal base is reached, thus recreating a relationship between the dental (over-jet) and skeletal (ANB) discrepancy, is it possible to perform a physiologic surgical repositioning of the basal bones and, at the end of the treatment, to have a global reharmonisation of the stomatognathic system.

In our research, we compared the effectiveness of interactive self-ligating appliances to obtain the decompensation of the upper and lower incisors' axes, compared with conventional ligating brackets, and their efficiency, by collecting and comparing the time needed to complete the presurgical preparation. Two groups of patients affected by dentoskeletal Class III who had undergone orthognathic surgery were tested, one treated with interactive self-ligating brackets and the other treated with conventional ligating appliances. Interactive bracket systems are a type of self-ligating brackets that have a particular behaviour: The wires used in the early stages of treatment have a small diameter and are not held against the base of the bracket with clips, acting as passive brackets. With the increase in thickness, the wire almost completely fills the bracket slot, and the clip retains it in the slot, acting as an active bracket. The setting was a public hospital.

As previously indicated, the wide use of self-ligating brackets in the current clinical practice is due to a hypothesised improved efficiency; however, the scientific literature is not uniform and conclusive about the superiority of one type of bracket system over the other ones.

From a methodological point of view, given the large number of features that should be analysed for each type of bracket system, we focused on a specific question. This study aimed to compare the two bracket systems to specifically test their behaviour during the orthodontic preparation in subjects with dentoskeletal malocclusion, when the muscular imbalance may have a role in hampering or slowing down the orthodontic movement [22,23].

As the differences in the mean values between the two groups investigated at T0 were not statistically significant, neither for the skeletal discrepancy nor for incisors' axes, the two groups included in the study were similar.

We compared the variation between pretreatment and presurgical values to evaluate a numeric parameter that estimates the efficiency in restoring the normal ranges for the incisors' axes. The difference between the pretreatment and presurgical values of the upper incisors' angle was not statistically significant between the groups. This finding agrees with two papers that reported that the mechanism to alleviate crowding is similar for conventional and self-ligating brackets [6,24].

Instead, the slightly lower correction of the IMPA angle in the self-ligating group, compared with the group with conventional ligating, was statistically significant. This finding confirms the data reported in the literature previously stating that the post-treatment IMPA angle, obtained with self-ligating systems, is slightly lower than the values obtained with conventional ligating. In our study, this finding has little clinical importance and should be consolidated with a greater number of subjects [13,25]. Other papers reported an increase in the post-treatment value of the IMPA angle, both with SLBs and CLBs; moreover, the greater the initial crowding, the greater the buccal inclination of the lower incisors in orthodontic patients [3,26].

Based on this finding, it should be useful to report that it is common in clinical practice to reverse the MBT lower incisors' brackets to obtain further +4° torque, which may help the lower decompensation in dentoskeletal Class III. In this study, the brackets were bonded with the standard orientation.

Indeed, the ideal model of dental movement has light, continuous forces that allow the sliding of the archwire into the bracket system; the dental movement occurs when the applied forces overcome the frictional resistance between the bracket and the wire; the lower the friction, the faster the movement of the teeth. Burrow demonstrated that friction is more related to the binding of the archwire against the corners of the bracket than to the sliding resistance, and that the treatment time may be reduced by lowering the friction [27].

Therefore, the reduction in the frictional resistance to sliding is an important challenge for clinicians, and many factors may affect the frictional resistance. Those related to the bracket include the geometry of the slot (mesiodistal size and the presence of rounded or sharp corners) and the physical properties of the manufactured material. The type of ligation, if metallic or elastomeric, and how tight the ligatures keep the wire into the bracket slot are also important. The factors related to the wire include the physical characteristics of the manufactured material and the thickness of the wire. The clinical severity of the arch could also have a role because crowding (and irregularities in general) and the deepening of the curve of Spee may affect the inter-bracket distance [1,28–32].

The mean time needed to reach decompensation in the group treated with self-ligating brackets was greater than three months, compared with the conventional ligating bracket group, but the difference was not statistically significant. Although many studies have reported equal performance between SLBs and CLBs in orthodontic patients, to date, the literature has not included reports of any comparisons among patients who have undergone presurgical orthodontics.

Two reasons could be the causes of this difference: the first is the imbalance of the neuromuscular forces always present in dentoskeletal malocclusion, which counteracts the direction of the orthodontic forces during presurgical orthodontics. The absence of ligatures, which is generally a factor that reduces the friction of the system, could express lighter forces than conventional ligating brackets and could slow down orthodontic movement. The other factor could be linked to the slower time required to express torque on teeth, compared with nonorthodontic–surgical treatments, as an effect of the neuromuscular imbalance.

As regards the time needed to achieve the decompensation, we sought to reduce the clinical biases that may affect the comparison, such as clinical factors. Hence, the sample was reduced for the strict selection criteria used to categorise the two groups as homogeneously as possible. The power of the study is obviously affected by its small sample size; therefore, this study can be considered a preliminary study.

To obtain more significant results on the topic investigated, the strict inclusion criteria necessary to avoid biases should be used in a study with a greater sample size, and probably a multicentre setting would help to increase the sample size.

The other limitations of this study are related to the retrospective nature of the study. In particular, the factors related to compliance of patients, such as regular presentation to the scheduled appointments, or the debonding rate, may affect the regular progression of the therapy and surely have a role in the overall treatment time. These variables were not collected in this study as they were not reported precisely in patient records.

We used Little's Irregularity index for the assessment of crowding, which does not consider the amount of levelling between the teeth. Therefore, further studies may be useful to also evaluate the effectiveness of levelling the arches, not only the effectiveness in improving crowding and performing dental compensation. A different index that includes the amount of the curve of Spee could be useful, instead of indexes that evaluate dental crowding only.

5. Conclusions

Both bracket systems proved effective in achieving the incisors' decompensation at the end of the presurgical orthodontic preparation in Class III patients. While no statistically significant differences were found in the correction of the upper incisors, the values of the IMPA, which were slightly lower, resulted in significantly different results.

Although the time needed to achieve the presurgical preparation was shorter in the group with conventional ligating brackets, this difference was not statistically significant. As there was not a clear superiority of a bracket system over the other, the differences between the two groups may depend on patient characteristics, such as the initial crowding or population; the treatment choices made by the operator, such as the time to change an archwire; or mechanics; however, they do not depend on the amount of the dental compensation.

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Conflicts of Interest: The authors declare no conflict of interest.

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