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Adult patients' adjustability to orthodontic appliances. Part I: a comparison between Labial, Lingual, and Invisalign™

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SUMMARY This prospective study examined the adult patient's perception of recovery after insertion of three types of orthodontic appliances: Buccal, Lingual and Invisalign.

The sample consisted of sixty-eight adult patients (45 females and 23 males) who comprised three groups: 28 Buccal, 19 Lingual, and 21 Invisalign patients. After appliance insertion, patients completed a Health-Related Quality of Life questionnaire daily for the first week and again on day 14, in order to assess patients' perception of pain and analgesic consumption. In addition, four areas of dysfunction were assessed: oral dysfunction, eating disturbances, general activity parameters, and oral symptoms.

Lingual appliance was associated with more severe pain and analgesic consumption, the greatest oral and general dysfunction, and the most difficult and longest recovery. The Invisalign patients complained of relatively high levels of pain in the first days after insertion; however this group was characterized by the lowest level of oral symptoms and by a similar level of general activity disturbances and oral dysfunction compared to the Buccal appliance.

Many Lingual and some Buccal patients did not reach a full recovery from their eating difficulties by the end of the study period.

The present study provides information to adult patients and clinicians assisting them in choosing the most appropriate treatment modality in relation to Health-Related Quality of Life parameters.

Introduction

Current advances in orthodontics have broadened the possibilities of invisible orthodontic appliances offered to adult patients. For some patients, aesthetic considerations during treatment are as important as other factors, such as comfort, pain, cost, or length of treatment.

Traditional labial appliances (Buccal) remain the main orthodontic appliance used. The introduction of the lingual appliance (Lingual) provided a significant aesthetic advantage to patients (Fujita, 1978), but functional difficulties and a prolonged adaptation reduced its use until recent years (Sinclair *et al.*, 1986; Creekmore, 1989). In 1997, the Invisalign™ appliance was introduced. This appliance is aesthetically superior to the labial appliance and allows for its removal for eating and cleaning (Wong, 2002). The main disadvantages of the invisible techniques (Lingual and Invisalign™) are a higher cost and technical limitations. The mean accuracy of tooth movement in Invisalign™ is 41 per cent. The most accurate movement is associated with lingual constriction (47.1 per cent), and the least accurate movement is extrusion (29.6 per cent; Kravitz *et al.*, 2009). In addition, Invisalign™ patients demonstrated significantly better periodontal indices than did those with fixed lingual appliances, which indicates a lower periodontal risk throughout treatment (Miethke and Brauner, 2007).

In recent years, adult orthodontic treatments™ have become increasingly popular, and many prefer the Lingual or Invisalign™ techniques. Several studies reported that women under 40 preferred Lingual over Buccal for both aesthetic and professional reasons (Hohoff *et al.*, 2003; Fritz *et al.*, 2004). A similar study found a predominance of 20–30 year old females who selected Invisalign™ over Buccal or Lingual. Their choices were due to aesthetic (compared with Buccal) and functional (compared with Lingual) considerations (Nedwed and Miethke, 2005; Miethka *et al.*, 2003).

Several studies have assessed patient adaptation to various appliances. In a comparison between Buccal and Lingual, no differences in adaptation time were noted, and both appliances needed a month to adjust. Lingual patients reported greater speech disturbances and an irritation of the tongue (Caniklioglu and Oztürk, 2005). Other studies reported no differences in the consumption of analgesics but greater cheeks and lip discomfort in the Buccal patients

(Wu *et al.*, 2010). Additional studies found the adaptation time to be shorter for Lingual versus Buccal appliances (Fritz *et al.*, 2004).

A comparison between Invisalign™ and Buccal appliances demonstrated prominent differences. Buccal patients had greater discomfort, more pain, analgesic consumption, and more functional and psychological disturbances (Miller *et al.*, 2007). In addition, the adaptation time was only 1 week long for the Invisalign™ patients (Nedwed and Miethke, 2005).

Patients are highly involved in the selection of orthodontic techniques. Recently, patients have taken an active interest, have high expectations, and emphasize the element of quality of life throughout treatment.

Several studies investigated the impact of medical and dental conditions on subjective well-being, using the health-related quality of life (HRQoL) instrument (Locker and Jokovic, 1996; O'Brien *et al.*, 1998; Cunningham and Hunt, 2001; Jokovic *et al.*, 2002).

To date, no studies have, to our knowledge, compared patients' adaptation to the three available appliances: Buccal, Lingual, and Invisalign™. This study compares patients' adjustability to these three orthodontic appliances, which are assessed in several areas of adaptation and function.

Materials and methods

The samples were obtained from 68 adult patients (45 females and 23 male) with 28 in the Buccal group, 19 in the Lingual group, and 21 in the Invisalign™ group. Consecutive patients were recruited prospectively from the orthodontic clinic in the Hebrew University-Hadassah School of Dental Medicine and from two private clinics. Most of the patients were treated by two senior clinicians. Inclusion criteria included: Consecutive adult patients (age range 18–60 years) who needed comprehensive orthodontic treatment. The study was approved by the Hadassah Medical Center ethics committee for clinical trials, and informed consent was obtained from all participants after an explanation of the study.

The buccal appliance was a straight wire appliance, 022 × 028 slots, manufactured by GAC and Ormco. The Lingual appliance was Incognito. The wire was 014 Nitinol wire for all Buccal and Lingual patients.

After the appliance insertion, patients completed a daily HRQoL questionnaire for the first week and again on day 14. The questionnaire (Appendix 1) has been used and validated in previous studies (Chaushu *et al.*, 2004, 2005, 2007). It was designed to assess the patients' perception of pain severity and their analgesic consumption. The degree of pain was assessed using a visual analog scale of 1–10 with 1–3 representing mild pain, 4–7 representing moderate pain, and 8–10 representing severe pain. Analgesic consumption was based on the patients' self-reports.

Four additional areas of dysfunction were assessed specifically:

1. Oral dysfunction, such as difficulties in speaking, swallowing, or opening the mouth.
2. Disturbance in eating, such as difficulties in eating, a reduced enjoyment of food, and a change in taste.
3. General activity measures, such as sleeping, the ability to participate in routine daily activities, and school/work attendance.
4. Oral symptoms, such as sores on the tongue, cheeks, or lip, bad tastes/smells, and food accumulation in the mouth.

These parameters were assessed on a five-point scale: 1 = no instances, 2 = few instances, 3 = some instances, 4 = several instances, and 5 = numerous instances. In order to perform statistical analyses of the four areas of dysfunction, a mean score of the items comprised in each area was obtained.

Recovery time, which was defined as the number of days needed to achieve mild or no pain, was calculated and compared between the three groups.

Statistical analysis

Data analysis was carried out using the Statistical Package for Social Science (SPSS) computer software for Windows.

Two-way analysis of variance (ANOVA) for repeated measures (appliances × time) and Bonferroni *post hoc* tests were used to compare between the groups for the quantitative variables measured from day 1 to day 7. Multiple analysis of variance (MANOVA), univariate ANOVA, and Bonferroni *post hoc* tests were used for the recovery variables.

Chi square tests were used to compare categorical variables.

Results

Three distinct sample groups with a total of 68 adult orthodontic patients were collected. The patient age range was 18–60 years (average age 30.3), and there were 45 females and 23 males. The Buccal group was the largest group (N = 28), which consisted of an identical numbers of males and females. The Invisalign™ group (N = 21) consisted of 5 males and 16 females, and the Lingual group (N = 19) consisted of 4 males and 15 females. The difference in the male to female ratio between the groups was not significant.

Average pain levels

Pain levels significantly decreased from the first to the seventh day ($F_{6,35}$ = 11.55, $P < 0.001$). Pain levels were consistently higher in the Invisalign™ and Lingual groups compared to the Buccal group, but there were no significant statistical differences between the groups (Figure 1 and Table 1).

Severe pain

On day 1, the highest percentage of patients who reported severe pain was found in the Invisalign™ group (38.1 per cent) but the differences compared to the other groups were not significant. On day 2, a dramatic increase was found in the percentage of patients suffering from severe pain among the Lingual patients (61.5 per cent). The difference between the Buccal and Lingual groups was statistically significant (P = 0.003). In general, a small percentage of Buccal patients reported severe pain (9–10 per cent on day 1–4, 5 per cent on day 5, and 0 per cent on days 6–14; Figure 2).

Analgesics

The consumption of analgesics was the highest in the Lingual group and reached 36.8 per cent on day 1 even though this percentage was not significantly different from the other groups. The pattern of analgesic consumption was similar in the Buccal and Lingual groups with a continuous reduction in analgesic use throughout the study. By day 5, a steady 5.2 per cent of Lingual patients were still using analgesics, and this continued until the end of the study. In the Buccal group, analgesic consumption was consistently the lowest throughout the study and reached 0 per cent by day 4. The Invisalign™ group showed a different pattern of analgesic use with an increase between days 1–3 and 4–5, but by day 6, analgesic consumption reached 0 per cent.

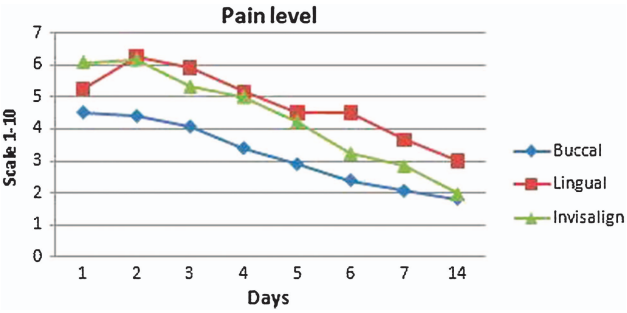

Figure 1 Average pain levels in the three groups.

Oral dysfunction

To assess oral dysfunction, we examined difficulties in speech, swallowing, and opening of the mouth (Figure 3 and Table 1). Levels of oral dysfunction significantly decreased over time ($F_{6,58}$ = 8.46, P < 0.001); there was a significant difference between the groups ($F_{2,63}$ = 5.87, P = 0.005) and no interaction. Levels of oral dysfunction were significantly higher in the Lingual group compared to the Buccal group (P = 0.004) and to the Invisalign™ group (P = 0.050). There were no significant differences between the last two groups.

Disturbances in eating

To assess disturbances in eating, we examined difficulties associated with eating, a reduced enjoyment of food, and a change in taste (Figure 4 and Table 1). Levels of disturbances

Table 1 Means (and standard deviations) of pain (scale: 1–10), oral dysfunction, disturbances in eating, general activity, and oral symptoms (scale: 1–5) in the three types of orthodontic appliances during the first week and on day 14 after insertion

Appliance	Day	Pain level	Oral dysfunction	Disturbances in eating	General activity	Oral symptoms
Buccal	1	4.50 (2.50)	1.86 (0.74)	3.26 (1.14)	1.55 (0.63)	2.17 (0.66)
Lingual		5.25 (3.17)	2.35 (1.14)	4.00 (0.82)	2.04 (1.00)	2.13 (0.71)
Invisalign™		6.08 (2.84)	2.21 (0.85)	2.37 (1.36)	1.89 (0.98)	1.58 (0.72)
Buccal	2	4.39 (2.66)	1.64 (0.87)	2.77 (1.18)	1.39 (0.56)	2.04 (0.64)
Lingual		6.25 (3.47)	2.50 (1.22)	3.82 (0.90)	2.13 (1.21)	2.26 (0.65)
Invisalign™		6.15 (2.58)	1.81 (0.70)	2.27 (1.19)	1.54 (0.90)	1.67 (0.72)
Buccal	3	4.06 (2.67)	1.56 (0.95)	2.63 (1.27)	1.35 (0.64)	2.04 (0.75)
Lingual		5.92 (3.40)	2.48 (1.17)	3.72 (0.94)	2.00 (1.03)	2.21 (0.61)
Invisalign™		5.31 (2.90)	1.86 (0.83)	1.98 (0.97)	1.48 (0.68)	1.74 (0.74)
Buccal	4	3.39 (2.68)	1.53 (0.90)	2.57 (1.28)	1.19 (0.42)	1.98 (0.75)
Lingual		5.17 (2.98)	2.35 (0.97)	3.65 (0.95)	1.89 (1.00)	2.13 (0.47)
Invisalign™		5.00 (2.97)	1.75 (0.78)	1.79 (1.03)	1.33 (0.68)	1.67 (0.67)
Buccal	5	2.89 (2.35)	1.42 (0.80)	2.49 (1.20)	1.17 (0.40)	1.91 (0.74)
Lingual		4.50 (2.68)	2.11 (0.89)	3.61 (1.02)	1.64 (0.90)	2.04 (0.56)
Invisalign™		4.23 (2.86)	1.51 (0.69)	1.54 (0.80)	1.28 (0.55)	1.52 (0.60)
Buccal	6	2.39 (1.82)	1.33 (0.65)	2.36 (1.18)	1.05 (0.17)	1.87 (0.68)
Lingual		4.50 (2.91)	2.17 (0.97)	3.57 (0.93)	1.53 (0.72)	2.02 (0.55)
Invisalign™		3.23 (2.59)	1.35 (0.56)	1.54 (0.87)	1.26 (0.63)	1.49 (0.56)
Buccal	7	2.06 (1.66)	1.26 (0.43)	2.16 (1.16)	1.03 (0.14)	1.80 (0.61)
Lingual		3.67 (2.39)	1.93 (0.83)	3.27 (0.97)	1.50 (0.77)	2.05 (0.53)
Invisalign™		2.85 (2.41)	1.33 (0.56)	1.46 (0.77)	1.24 (0.52)	1.40 (0.52)
Buccal	14	1.81 (1.52)	1.27 (0.48)	2.01 (1.13)	1.03 (0.11)	1.81 (0.63)
Lingual		3.00 (1.63)	1.69 (0.92)	3.12 (1.02)	1.28 (0.65)	1.83 (0.51)
Invisalign™		1.50 (0.71)	1.10 (0.16)	1.23 (0.64)	1.04 (0.09)	1.27 (0.39)

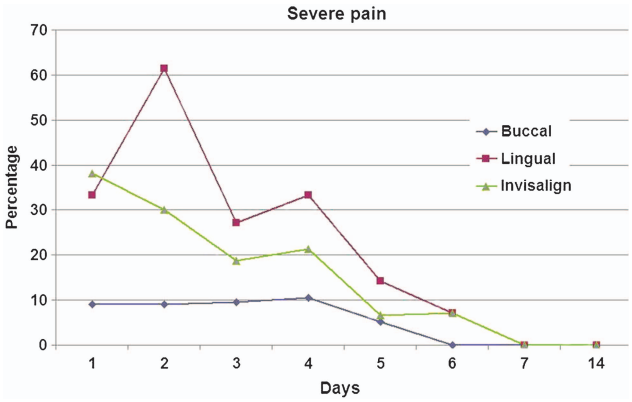

Figure 2 Severe pain in the three groups.

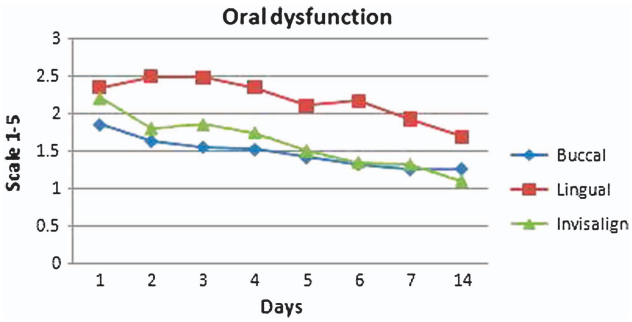

Figure 3 Oral dysfuction in the three groups.

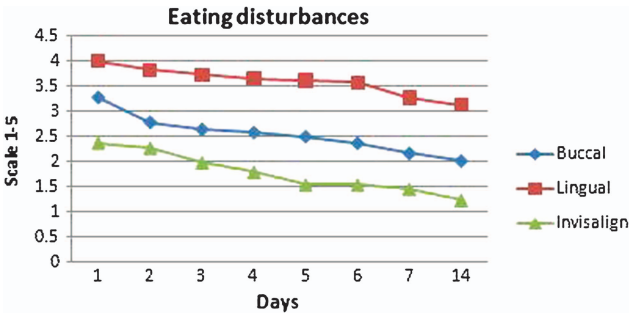

Figure 4 Eating disturbances in the three groups.

in eating significantly decreased over time ($F_{6,57}$ = 9.87, P < 0.001). There was a significant difference between the groups ($F_{2,62}$ = 16.16, P < 0.001) and no interaction: The levels were significantly higher in the Lingual group compared to the Buccal group (P = 0.003) and to the Invisalign™ group (P < 0.001). The levels were also significantly higher in the Buccal group compared to the Invisalign™ group (P = 0.031).

General activity

To examine general activity, we assessed sleeping, concentration during work/studies, absences from work/studies, and difficulties in daily activities (Figure 5 and Table 1). Levels of general activity significantly decreased over time ($F_{6,58}$ = 5.45, P < 0.001). There was a significant difference between the groups ($F_{2,63}$ = 5.05, P = 0.009) and no interaction: Levels of general activity were significantly higher in the Lingual group compared to the Buccal group (P = 0.007) but not to the Invisalign™ group.

Oral symptoms

To assess oral symptoms, we examined sores on the tongue, cheek, or lip, bad tastes/smells, and food accumulation (Figure 6 and Table 1). Levels of oral symptoms significantly decreased over time ($F_{6,57}$ = 4.13, P = 0.014). There was a significant difference between the groups ($F_{2,62}$ = 5.26, P = 0.008) and no interaction: levels of oral symptoms were significantly lower in the Invisalign™ group compared to the Buccal group (P = 0.047) and to the Lingual group (P < 0.010).

Recovery time

Lingual patients had a significantly longer recovery time than did Buccal and Invisalign™ patients for most parameters (Figure 7). MANOVA yielded a significant difference between the groups across all recovery parameters (overall $F_{32,102}$ = 3.37, P < 0.001). Bonferroni tests showed that Lingual patients had a significant longer recovery time compared to Buccal patients regarding difficulty in speaking (P = 0.012), limitation in eating (P = 0.018), disturbance in school/work (P = 0.018), and missing

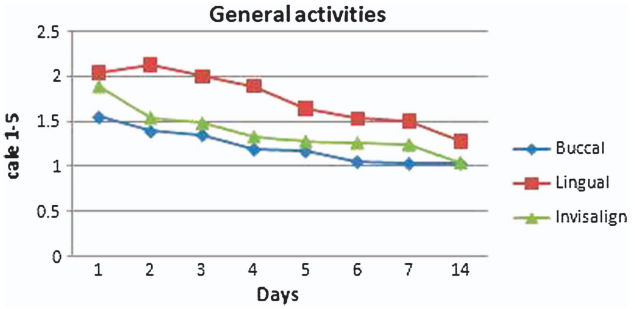

Figure 5 General activity in the three groups.

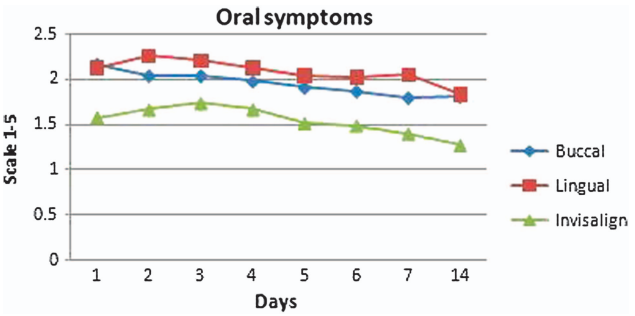

Figure 6 Oral symptoms in the three groups.

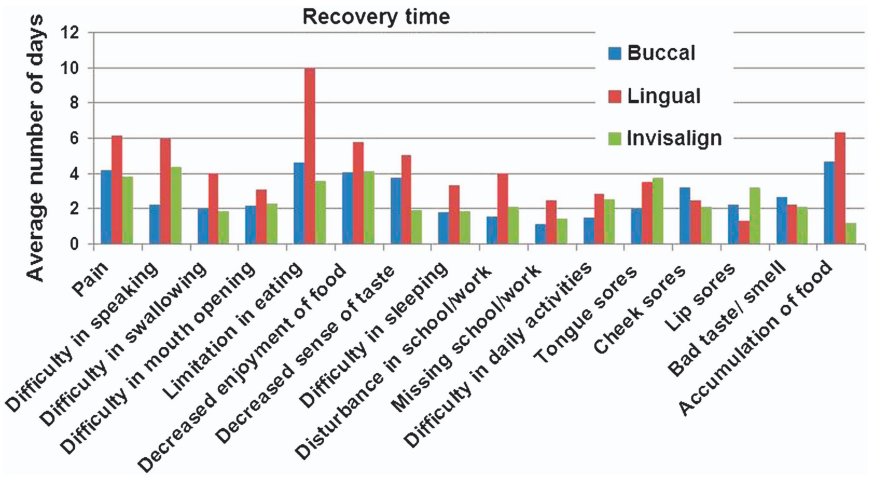

Figure 7 Recovery time for each parameter.

school/work (P = 0.035). Lingual patients also had a significant longer recovery time compared to Invisalign™ regarding difficulty in swallowing (P = 0.048), limitation in eating (P = 0.003), and accumulation of food (P = 0.012).

Many of the patients from the Lingual (41–76%) and Buccal (25–36%) groups did not report a complete recovery in their eating disturbances even after 14 days. Failure to accomplish recovery on day 14 was significantly correlated with eating disturbances and oral symptoms ($P < 0.05$).

A significant percentage of patients did not recover from their sores by the end of the study, depending on the type of appliance and the location of the sores.

Discussion

This study compared three orthodontic appliances (Buccal, Lingual, and Invisalign™) with respect to the adult patient's perception of recovery during the first 2 weeks after the insertion of the appliance.

Both Lingual and Invisalign™ groups included a higher percentage of female patients than did the Buccal group. A similar ratio was found by Fritz *et al.* (2004) and Nedwed and Miethke (2005).

Random adult patients, some of whom unwilling or unable to compromise their esthetics, are rarely willing to comply with random assignment of the treatment modality (Buccal, Lingual, or Invisalign™). This constraint limits the ability to fully randomize the study. The patient's choice may reflect personality traits, which may also affect their experience after appliance insertion. This possible linkage is currently a subject of a parallel study on the same sample.

In order to avoid the influence of different clinicians on patients' response, we included only patients that were treated by two senior clinicians, who have been working together for many years and shared similar philosophy and technique.

The 14 day period was chosen to reflect immediate post-treatment effect, and because this period had to be shorter than the shortest activation time among the three treatment modalities (in this case, it was shorter than the 2 weeks activation interval for Invisalign™).

Average levels of pain were higher in the Lingual and Invisalign™ groups, although the differences did not yield statistical significance. The analgesics consumption paralleled the dynamics of the pain levels. Wu *et al.* (2010) also found greater consumption of analgesics in Lingual patients, despite no statistically significant differences in pain levels between Buccal and Lingual patients.

During the first week of treatment, Miller *et al.* (2007) found a greater number of Buccal patients that suffered from severe pain and had a high rate of consumption of analgesic, compared with Invisalign™ patients. In the current study, we found the opposite results—Invisalign™ patients reported more severe pain than Buccal patients, similarly to Lingual patients. Our findings may be due to a greater mechanical force that was applied in the Invisalign™ technique early into treatment. In the Buccal technique, the wire's flexibility may result in a more gradual and lighter force. In both studies, the pain subsided after a week, and the recovery time was similar in both groups.

We found significantly higher oral dysfunction levels and much longer recovery time in the Lingual group than in both Buccal and Invisalign™ groups. This result is similar to Caniklioglu and Oztürk (2005), who compared Lingual and Buccal patients. The levels of impairment in oral function with Invisalign™ were similar to Buccal.

Significant differences between the groups were found regarding eating disturbances. Similar to Caniklioglu and Oztürk (2005), Lingual patients reported more eating disturbances and a longer recovery time. Many of the patients did not achieve a full recovery within 14 days. The impairment associated with disturbances in eating was the lowest with Invisalign™. This result is not surprising

since these patients are instructed to eat without the aligners. Some degree of discomfort during eating may be related to teeth sensitivity during orthodontic movement.

Wu *et al.* (2010) did not find a difference in sleep patterns between Lingual and Buccal patients, but we found more sleep disturbances in the Lingual group. Furthermore, these patients reported greater general activity disturbances than patients in the other groups. General activity can be viewed as the end result of the various disabilities and dysfunctions mentioned above. Lingual patients suffer more tongue injuries (Caniklioglu and Oztürk, 2005; Wu *et al.*, 2010), therefore, a larger disruption in general activity can be expected because the tongue is active 24 hours per day and, thus, causes constant irritation and soreness. The levels of impairment in oral symptoms and general activities with Invisalign™ were similar to Buccal patients and significantly less than Lingual patients.

When these results are considered, we need to contemplate a difference in the complexity of the cases within the 3 groups: While the Buccal and Lingual patients presented with similar complexity and irregularity index, the Invisalign™ cases typically had lower irregularity index and complexity due to the limitations of the technique. This inherent difference may have an effect on patients' perception of recovery, i.e. since Invisalign™ is generally limited to less complicated cases, this may have a bias effect on the reaction and perception of the patients.

In summary, the Lingual appliance was associated with more severe pain and analgesic consumption, the greatest oral and general dysfunction, and the most difficult and longest recovery. The Invisalign™ patients complained of relatively high levels of pain in the first days after insertion; however, this group was characterized by the lowest level of oral symptoms and by a similar level of general activity disturbances and oral dysfunction compared to the Buccal appliance.

These findings are important for potential adult orthodontic patients and clinicians. These details are not less important than the clinical effectiveness and the aesthetic considerations of each method. The results of this study may assist patients and clinicians to choose the most appropriate treatment modality in relation to HRQoL parameters.

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Appendix 1: Health-related quality of life questionnaire

You have received an orthodontic appliance. To improve the quality of care, it is important for us to know how the

appliance has affected you. Please take a few moments to complete this survey. Please choose the number that corresponds to your assessment over the past 24 hours. Rate the worst pain you have felt during the past 24 hours on a scale of 1 to 10 (1—not at all, 10—very much). Have you taken any medication to relieve pain today? (0 = no, 1 = yes). For the following questions, please use this rating: 1 = no instances, 2 = few instances, 3 = some instances, 4 = several instances, 5 = numerous instances. Has it been difficult to speak today? Has it been difficult to swallow today? Has it been difficult to open your mouth today? Were there any foods you could not eat today? Have you enjoyed your food today? Have you noticed a change in your sense of taste today? Was it difficult to sleep last night? Does the appliance disturb you at work or when studying today? Has it been difficult to continue your daily activities today? Do you have sores on your tongue? Do you have sores on your cheeks? Do you have sores on your lip? Have you had a bad taste or bad smell in your mouth today? Has there been any food debris under the appliance today?