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Research Article

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A Study of the Quality of Finish of Lingual versus Labial Bracket Systems As Measured By the Objective Grading System: A Retrospective Study in a University Orthodontic Clinic

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Abstract

Objective: *The purposes of this study were to determine the quality of final orthodontic treatment outcome and average treatment time with fixed lingual brackets compared to labial brackets. Our hypothesis was that labial fixed appliances produce a higher quality of final treatment outcome, and a shorter average treatment time compared to lingual fixed appliances.*

Materials and Methods: *This was a retrospective study of matched pairs. Records of twenty subjects treated with lingual appliances were included. These were paired with twenty patient records of subjects in fixed labial appliances with matching initial discrepancy index (DI) (±5 points), Angle classification (within one-half step), number of extracted teeth, and age. Final models were scored using the eight criteria of the American Board of Orthodontics' Objective Grading System (OGS) and treatment time was recorded in number of days.*

Results: *The mean difference in OGS scores between groups was 2.00 ± 8.89 points with a mean OGS score of the labial and lingual fixed appliance groups of 21.6 ± 7.45 and 19.6 ± 6.43, respectively. This difference was not statistically significant ($p = 0.33$). Lingual subjects' treatment time was an average of 4.25 ± 213.78 days less compared to their matched labial subjects. This difference was not significant ($p = 0.93$). A statistically significant difference was found in the buccolingual inclination subcategory of the OGS. The mean difference in the buccolingual inclination score of lingual subjects was 1.90 ± 3.52 points higher than labial subjects ($p = 0.03$).*

Conclusion: *Lingual fixed appliance subjects had no significant difference in treatment time and / or treatment outcome as measured by OGS when paired with labial fixed appliance subjects, however, they did have significantly higher buccolingual inclination discrepancies.*

Keywords: Customized braces, Incognito™, Lingual orthodontics

Introduction

The number of adults seeking orthodontic care is increasing [1]. Adults often request esthetic options for their treatment. Orthodontic treatments that offer better esthetics include clear aligners and lingual braces [1,2].

Clear aligners, while more esthetic than braces, have treatment limitations. Invisalign's predictability (Invisalign™ San Jose, CA) for achieving specific orthodontic tooth movements has been measured between 29.6% (extrusion) and 47.1% (constriction) as compared to the computer generated outcome prediction [3].

Lingual braces were introduced in the 1970's and were the first truly invisible orthodontic appliances. However, difficult intraoral access resulted in increased chair time and patient discomfort [4-6]. Lingual patients report more initial discomfort, tongue irritation and speech difficulties [7]. However, initial discomfort caused by both labial and lingual braces decreases over time [8].

Treatment effectiveness with early lingual braces was often compromised [9]. However, modern lingual systems use computer-aided design/computer-aided manufacturing (CAD/CAM) technology to customize treatment [5,10]. The Incognito™ system (3M Monrovia, CA) uses CAD/CAM to create both custom brackets and archwires to improve outcomes and reduce treatment time [11-13].

The American Board of Orthodontics (ABO) developed the Discrepancy Index (DI) to evaluate the complexity of orthodontic cases (pre-treatment) and the Objective Grading System (OGS) to evaluate treatment quality of finished cases [14,15]. The ABO-OGS has the most stringent standards compared to other indices and is the outcome measure used in this study.

To date, there has not been a comparison of lingual braces and labial braces regarding quality and efficiency of treatment in a population with a variety of malocclusion types. The purposes of this study were to compare the quality of final treatment outcome and average treatment time in subjects with diverse malocclusions treated with lingual and labial brackets.

Material and Methods

All treatment modalities investigated in this study are in general use in patient care. No experimental methods or products were utilized. The protocol for this study was approved by the Colorado Multiple Institution Review Board (COMIRB), protocol number 16-1629, effective August 20, 2018.

This investigation was a retrospective, matched pair, controlled study of orthodontic outcomes. Pairs of patient records (one from the lingual study population and one from the labial study population) were matched for DI, number of extracted teeth, age, and Angle classification (Table 1).

Table 1: Baseline patient characteristics

Matched Pair	Appliance	Age at Start	Gender	EXT Pattern	Angle Class	DI
1	Lingual	26.7	Female	None	I	7
	Labial	22.0	Female	None	I	10
2	Lingual	31.5	Female	None	I	2
	Labial	28.4	Female	None	I	2
3	Lingual	15.5	Female	U4s, L5s	R: II 50% L: I	27
	Labial	18.3	Female	U4s, LR4	R: I L: II 100%	29
4	Lingual	19.5	Female	U4s	R: II 75% L: II 100%	26
	Labial	25.0	Female	U4s	R: II 75% L: II 100%	29
5	Lingual	17.3	Female	U4s	II 75%	17
	Labial	16.1	Female	U4s	II 100%	16
6	Lingual	47.6	Female	None	I	9
	Labial	43.8	Female	None	I	7
7	Lingual	36.1	Male	None	II 100%	8
	Labial	43.6	Male	None	`	9
8	Lingual	32.2	Female	None	I	21
	Labial	20.5	Female	None	I	17
9	Lingual	28.6	Female	None	I	9
	Labial	35.4	Female	None	I	9
10	Lingual	30.0	Male	Lower Incisor	R: III 50% L: III 50%	12
	Labial	49.6	Male	Lower Incisor	R: III 50% L: I	19
11	Lingual	21.4	Male	None	I	5
	Labial	25.9	Male	None	I	3

12	Lingual	19.6	Female	None	I	14
	Labial	23.6	Female	None	I	13
13	Lingual	61.2	Female	None	I	16
	Labial	59.7	Female	None	I	11
14	Lingual	42.6	Female	U4s and LR4	R: I L: II 100%	11
	Labial	36.1	Male	UR4, L4s	R: I L: II 50%	14
15	Lingual	31.6	Female	U/L 4s	R: II 50% L: II 25%	23
	Labial	29.6	Female	U/L 4s	I	19
16	Lingual	45.1	Female	None	R: II 100% L: II 75%	21
	Labial	38.2	Female	None	R: II 100% L: II 75%	26
17	Lingual	43.3	Female	None	Class II 100%	19
	Labial	33.5	Female	None	R: II 25% L: II 50%	14
18	Lingual	52.4	Female	None	I	11
	Labial	50.9	Female	None	R: II 25% L: I	14
19	Lingual	31.3	Female	None	I	11
	Labial	28.7	Female	None	I	6
20	Lingual	27.1	Male	Lower Incisor	I	11
	Labial	26.8	Male	Lower Incisor	I	11

The DI score was matched ± 5 points. Up until 2018, the ABO required three cases with a DI score of 20 or greater and three cases with a DI score of 10 or greater for the Case Report Examination portion of the ABO exam. For this reason and due to a large range of possible scores, matching patient records with a DI score ± 5 points was chosen to be representative of subjects with similar pretreatment malocclusion complexity.

Angle classification was determined by initial plaster models. Patient records were matched as Class I, Class II, or Class II with a subdivision right or left. In cases where an exact match could not be identified, labial subjects were matched within one-half step of the lingual patient's Angle classification. Cases treated with extractions were matched by the number of premolars extracted. Age was matched; however, almost all subjects in this study were adults where growth is not a large factor in treatment.

The investigator was blinded for assessment. A numerical code was assigned to each patient record for research blinding utilizing Microsoft Excel's® Random Number Generator. The identity of the patient's name and matching code was kept in a secure location. The investigator scored each final model and panoramic radiograph using the ABO OGS.

The orthodontic records, including pre-treatment and post-treatment models of a total of 40 subjects (20 matched pairs) treated at a university orthodontic clinic, were examined. All subjects underwent comprehensive orthodontic treatment.

Patient consent was obtained for use of the records if analysis was completed during active treatment. All subjects signed an AAO Informed Consent form consenting use of their records for research purposes.

Inclusion criteria included treatment of at least one arch with custom lingual brackets or both arches with labial brackets, full orthodontic records including pre-treatment plaster models and cephalometric radiograph, and post-treatment plaster models and panoramic radiograph.

Exclusion criteria at the start of treatment were as follows: no impacted teeth first molar to first molar, no orthognathic surgery anticipated, and no distalizing appliances needed.

There were no health-related exclusion criteria. Neither sex/gender nor ethnicity/race was used as exclusion criteria. There was no randomized allocation.

Materials used included: computer-designed lingual orthodontic appliance Incognito™ Full (3M Unitek, Monrovia, CA), conventional labial orthodontic appliances including Clarity™ (3M Unitek, Monrovia, CA); Victory Series™ (3M Unitek, Monrovia, CA), Avex™ (Opal, South Jordan, UT), Damon Q™ (Ormco, Orange, CA), In-Ovation™ C (Dentsply Sirona, York, PA), and In-Ovation™ R (Dentsply Sirona, York, PA); ABO Measuring Gauge, ABO calibration models; plaster initial and final models; and Dolphin Imaging (Planmeca, Helsinki, Finland).

Group 1 was selected from the records of patients with comprehensive lingual treatment involving at least one full arch of lingual brackets.

Group 2 was selected from records of patients receiving treatment of upper and lower arches with labial fixed appliances. Matching inclusion criteria were: age (± 11 years), initial Angle classification, initial Discrepancy Index (±5 points), and extraction pattern.

The ABO discrepancy Index (DI) was calculated and recorded from pre-treatment records by a single examiner. This score was used as one of the criteria for creating paired matches (scores ± 5 points) between the lingual bracket population and labial bracket population.

The primary outcome measures were the relative quality of treatment result, which was measured by OGS, and total treatment time. The OGS evaluates post-treatment dental casts and radiographs for each

group were scored using eight criteria established by the ABO. Length of treatment for the test group was determined as the span of time from the initial bonding of brackets to debond. The initial appliance placement and removal dates were recorded and total treatment time was converted to days. The examiner was calibrated using the ABO measuring gauge and the calibration casts provided by the College of Diplomats of the American Board of Orthodontics.

A pilot study determined the OGS standard deviation for the sample size calculation for matched pairs. Final casts and panoramic radiographs were assessed using the ABO OGS on five randomly selected subjects treated with the Incognito™ appliance. From the results, the Coefficient of Reliability between the two evaluators was calculated as 0.80 with a standard deviation of 3.96 (Statistical Solutions) [16]. With a power of the test of 0.80, alpha value of 0.05, a significant difference in OGS of 5, and a standard deviation of 4, the sample size was calculated to be 11 matched pairs. Given the reliability of 80% between evaluators, the number of matched pairs was increased by 20% to achieve 13 pairs per experiment. Assuming a decrease in availability of records and cases ready for analysis, a sample of 20 matched pairs was studied.

Because the DI is a summation of categories measuring the "discrepancy" from normal, two subjects may have different malocclusion types with the same DI score. Because of this, in order to more appropriately match types of malocclusions, other matching criteria were used in addition to DI. Subjects in each pair were matched for initial Angle classification, extraction spaces that would require closing (potentially adding more treatment time), and age.

Statistical Analysis

The means and standard deviations were calculated for treatment time. Despite the fact that DI score and OGS score are ordinal, mean and standard deviations were calculated as done by convention in previous literature. A student's paired t-test between the two groups was completed for OGS score, each OGS subcategory scores, and treatment time to detect statistically significant differences. To improve measurement reliability, five records from the sample were scored for OGS by the examiner prior to data collection, and rescored 1-2 weeks later to verify intra-examiner reliability. The method of Houston was used [16].

Results

A convenience sample of 898 patient records was assessed for eligibility. A database of 827 subjects treated with labial brackets and 71 subjects treated with lingual brackets was generated. Eight hundred and fifty eight subjects did not meet requirements to be enrolled as a matched pair due to their age, Angle classification, DI score, or extraction pattern. Twenty patient records were assessed as the Incognito™ lingual group and 20 patient records were assessed as the labial group to make 20 matched pairs (Figure 1).

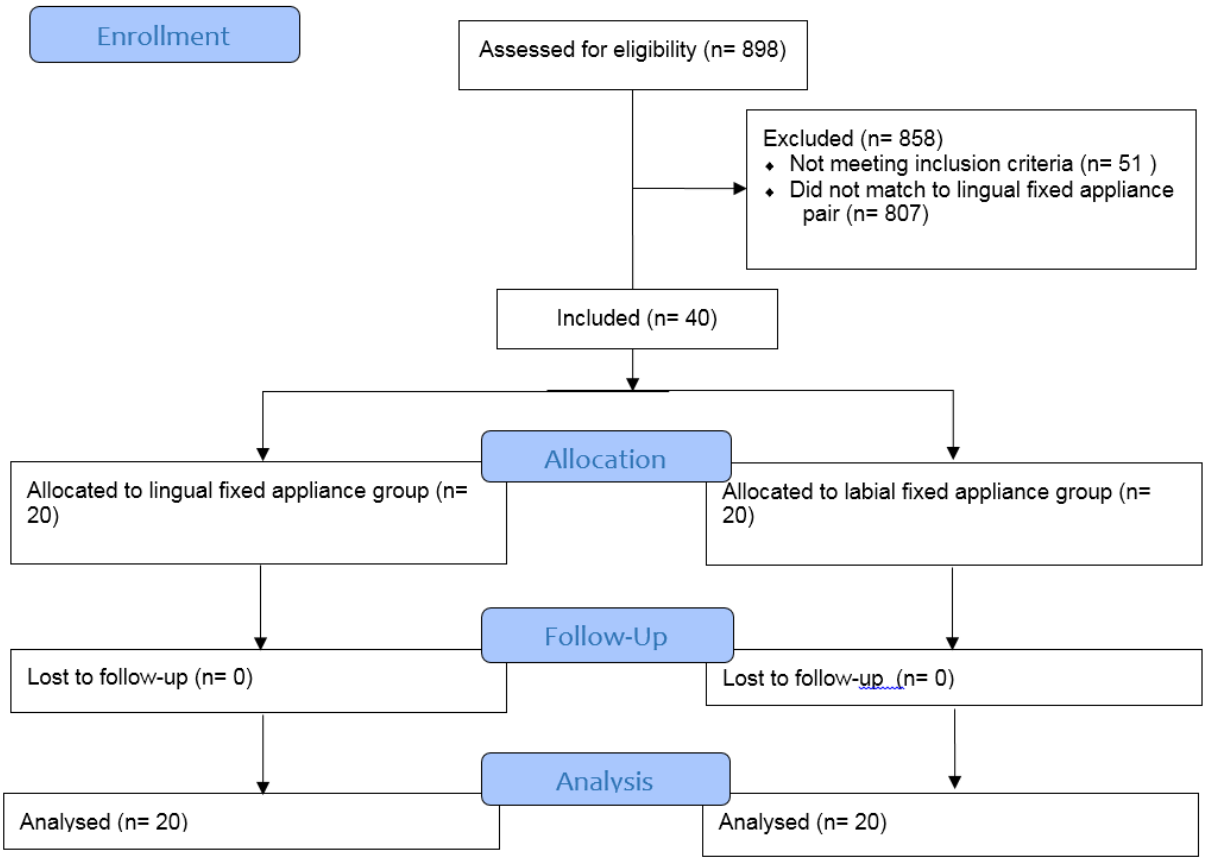

Figure 1: Consort Flow Diagram

Collection and analysis of patient records commenced in October 2016 and ended in October 2018.

Baseline information regarding age, gender, Angle classification, and DI score was collected. Information regarding the subject's treatment was limited to extraction pattern and bracket system (Table 1). No significant differences in age, Angle classification, and DI score were found between lingual and labial subjects in each matched pair.

Final records of all 20 matched pairs were analyzed. The overall OGS was recorded, as well as the scores for the eight subcategories: alignment, marginal ridges, buccolingual inclusion, overjet, occlusal contacts, occlusal relationships, interproximal contacts, and root angulation (Table 2).

Table 2: American Board of Orthodontics Objective Grading System results for each criteria

Matched Pair	Appliance	Overall OGS	Alignment/ Rotations	Marginal Ridges	BL Inclination	OJ	Occl Contacts	Occl Relationships	Interprox Contacts	Root Ang
1	Lingual	15	3	3	2	1	1	1	0	4
	Labial	17	4	4	1	1	3	0	0	4
2	Lingual	21	4	1	8	4	1	0	2	1
	Labial	10	0	2	2	0	2	2	0	2
3	Lingual	18	5	5	2	2	2	1	0	1
	Labial	24	4	3	3	3	6	3	1	1
4	Lingual	23	3	5	5	3	1	1	0	5
	Labial	29	1	5	5	4	4	8	0	2
5	Lingual	10	2	3	4	1	0	0	0	0
	Labial	10	0	3	1	1	0	3	0	2
6	Lingual	16	2	0	0	5	5	4	0	0
	Labial	18	1	8	0	0	4	3	0	2
7	Lingual	20	4	1	9	2	1	2	0	1
	Labial	29	2	7	0	3	8	9	0	0
8	Lingual	15	3	3	0	2	1	5	0	1
	Labial	15	0	3	1	3	3	1	2	2
9	Lingual	17	0	1	7	2	3	2	0	2
	Labial	27	6	6	8	0	5	0	0	2
10	Lingual	28	1	4	5	3	3	10	0	2
	Labial	27	4	5	4	10	3	0	0	1
11	Lingual	36	2	2	8	9	8	5	0	2
	Labial	19	1	7	1	3	5	0	0	2
12	Lingual	34	4	9	9	4	3	3	0	2
	Labial	26	5	8	4	1	6	2	0	0
13	Lingual	18	5	2	1	0	5	2	0	3
	Labial	25	2	4	2	3	8	3	0	3
14	Lingual	17	2	6	0	2	1	3	0	3
	Labial	11	3	1	0	3	0	2	0	2
15	Lingual	27	3	2	8	1	7	5	0	1
	Labial	17	3	4	1	4	2	2	0	1
16	Lingual	36	1	1	9	9	3	11	0	2
	Labial	11	3	0	3	1	2	1	0	1
17	Lingual	22	0	3	1	6	7	4	0	1
	Labial	22	4	2	5	4	0	7	0	0
18	Lingual	18	5	0	4	2	3	2	0	2
	Labial	15	1	3	4	2	0	3	1	1

19	Lingual	26	7	5	1	4	4	3	0	2
	Labial	22	2	5	0	2	8	3	0	2
20	Lingual	14	4	2	2	1	4	1	0	0
	Labial	17	0	4	2	4	0	1	0	6

MEAN (Lingual Group)	22	3	3	4	3	3	3	0	2
MEAN (Labial Group)	20	2	4	2	3	3	3	0	2
STANDARD DEVIATION (Lingual Group)	7.45	1.81	2.25	3.40	2.50	2.30	2.94	0.45	1.29
STANDARD DEVIATION (Labial Group)	6.43	1.81	2.21	2.13	2.23	2.78	2.58	0.52	1.40
MEAN DIFFERENCE (Lingual - Labial)	2.00	0.70	-1.30	1.90	0.55	-0.30	0.60	-0.10	-0.05
STANDARD DEVIATION (of the differences)	8.89	2.94	3.01	3.52	3.53	3.48	4.45	0.72	1.85
P-value (P < 0.05)	0.33	0.3	0.07	0.03	0.49	0.7	0.55	0.54	0.91

The mean difference in OGS scores between groups was 2.00 ± 8.89 points with a mean OGS score of the labial and lingual fixed appliance groups of 21.6 ± 7.45 and 19.6 ± 6.43, respectively. This difference was not statistically significant ($p = 0.33$).

Treatment time was calculated in number of days for all subjects (Table 3). Lingual subjects' treatment time was an average of 4.25 ± 213.78 days less compared to their matched labial subjects. This difference was not significant ($p = 0.93$).

Table 3: Treatment time in days

Matched Pair	Appliance	Tx Time (days)	Difference (Lingual - Labial)
1	Lingual	406	-159
	Labial	565	
2	Lingual	782	236
	Labial	546	
3	Lingual	667	-525
	Labial	1192	
4	Lingual	916	224
	Labial	692	
5	Lingual	1014	97
	Labial	917	
6	Lingual	462	-63
	Labial	525	
7	Lingual	700	69
	Labial	631	
8	Lingual	618	-173
	Labial	791	
9	Lingual	553	-32
	Labial	585	
10	Lingual	588	0
	Labial	588	
11	Lingual	574	-23
	Labial	597	
12	Lingual	476	-202

	Labial	678	
13	Lingual	504	-269
	Labial	773	
14	Lingual	994	-206
	Labial	1200	
15	Lingual	1141	385
	Labial	756	
16	Lingual	607	81
	Labial	526	
17	Lingual	807	14
	Labial	793	
18	Lingual	798	127
	Labial	671	
19	Lingual	891	289
	Labial	602	
20	Lingual	527	45
	Labial	482	

MEAN (Lingual Group)	701.25
MEAN (Labial Group)	705.50
STANDARD DEVIATION (Lingual Group)	207.55
STANDARD DEVIATION (Labial Group)	200.85
MEAN DIFFERENCE (Lingual - Labial)	-4.25
STANDARD DEVIATION (of the differences)	213.78
P-value ($P < 0.05$)	0.93

A statistically significant difference was found in the buccolingual inclination subcategory of the OGS when comparing lingual and labial subjects in each matched pair. The mean difference in the buccolingual inclination score of lingual subjects was 1.90 ± 3.52 points higher than labial subjects ($p = 0.03$).

Ten randomly selected final diagnostic casts were re-evaluated using the OGS one week after initial scoring. The average Houston Coefficient of Reliability was 0.88 for measurements in the eight subcategories (Table 4).

Table 4: Houston Coefficient of Reliability

Alignment/ Rotations	Marginal Ridges	BL Inclination	OJ	Occl Contacts	Occl Relationships	Interprox Contacts	Root Ang	Overall OGS
0.83	0.70	0.94	0.95	0.95	0.97	1.00	0.65	0.97
Average Houston Coefficient of Reliability of all 8 subcategories and overall OGS						0.88		

Discussion

This retrospective matched pair study compared the quality of treatment outcome and treatment length between lingual and labial bracket systems. Although no significant difference in overall OGS was found, lingual subjects had statistically significant buccolingual inclincation discrepancies when compared to labial subjects.

While the number of studies comparing the quality of treatment outcome between CAD/CAM lingual systems and labial systems is low, our results do agree with a recently published study which also found no overall difference in OGS [17]. Deguchi, et al. created matched pairs of 24 lingual patients and 25 labial patients with Class II malocclusions requiring extraction of four premolars. OGS was measured on final records and no significant differences were found. They did find that lingual patients had significantly higher scores in root angulation compared to labial patients [17]. This contrasts with the results of our analysis of OGS subcategories, with only the buccolingual inclination subcategory having a significant difference. However, their study specifically evaluated extraction cases for class II camouflage whereas our study included a broad sample of differing malocclusions.

One possible explanation for the increased buccolingual inclination discrepancy found in our study with the lingual braces may be associated with the ribbon arch wire design used by the Incognito™ system [18]. Lawson reported that the use of a ribbon wire in the Incognito™ system results in increased stiffness in the vertical dimension and decreased stiffness in the transverse dimension [19].

In addition, the thinner transverse dimension of the arch wire may cause the most posterior tooth to pull lingual causing "horizontal bowing" when using sliding mechanics to close extraction space [19] (Figure 2). These findings may help explain buccolingual discrepancies our study found in the posterior segments of lingual subjects.

Figure 2: Initial and progress occlusal views demonstrating the horizontal arch bowing seen with lingual braces

Overall treatment times in our study were highly variable among subjects and there was no significant difference in treatment time between labial and lingual groups. A variety of factors can contribute to the overall treatment time. The complexity of the initial malocclusion, the necessity of tooth extractions, the skill and number of operators involved in the treatment, and patient compliance are all considered factors in overall treatment time [20]. This study was conducted in a university orthodontic clinic with diverse and relatively high patient complexity levels (average DI=14), multiple operators, and extraction / non-extraction treatments. These factors likely contributed to the highly variable treatment times found in our study.

Conclusion

When orthodontic patients were treated with lingual appliances and paired with subjects treated with labial appliances of similar age, malocclusion, and extraction pattern outcomes included:

- There were no significant differences in overall treatment quality as measured by OGS
- Significantly higher buccolingual inclination discrepancies were found at the conclusion of treatment in the lingual braces group
- There were no significant differences in treatment time between the 2 groups

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References

1. Christensen LF (2015) Adults seeking orthodontic treatment: expectations, periodontal and TMD issues. Br Dent J 218: 111-117.
2. Shalish M, Cooper-Kazaz R, Ivgi I, Canetti L, Tsur B, et al. (2012) Adult patients' adjustability to orthodontic appliances. Part I: a comparison between labial, lingual, and Invisalign™. Eur J Orthod 34: 724-730.
3. Kravitz D, Kusnoto B, Begole EA, Obrez A, Agran B (2009) How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. Am J Orthod Dentofacial Orthop 135: 27-35.
4. Geron S (2008) Self-ligating brackets in lingual orthodontics. Sem in Orthod 14: 64-72.
5. Juneja P, Chopra S, Jayan B (2015) Self ligating lingual appliance. Med J Armed Forces India 71: 411-414.
6. Ling P (2005) Lingual Orthodontics: History, misconceptions and clarification. J Can Dent Assoc 71: 99-102.
7. Canikliogl C, Ozturk Y (2005) Patient Discomfort: A comparison between lingual and labial fixed appliances. Angle Orthod 75: 86-91.
8. Abby K, Wu Y, McGrath C, Wong R, Wiechmann D, et al. (2010) A comparison of pain experienced by patients treated with labial and lingual orthodontic appliances. Eur J Orthod 32: 403-407.
9. Bhandari P, Anbuselvan G, Karthi M (2014) History of lingual orthodontics-from past, present and future. J Integ Dent 2: 1-5.
10. Zinelis S, Sifakakis I, Katsaros C, Eliades T (2013) Microstructural and mechanical characterization of contemporary lingual orthodontic brackets. Eur J Orthod 36: 389-393.
11. Wiechmann D (2002) A new bracket system for lingual orthodontic treatment. J Orofac Orthop 3: 234-245.
12. Wiechmann D, Rummel V, Thalheim A, Simon J, Wiechmann L (2003) Customized brackets and archwires for lingual orthodontic treatment. Am J Orthod Dentofacial Orthop 124: 593-599.
13. Wiechmann D (1999) Lingual orthodontics (part 2): archwire fabrication. J Orofac Orthop 60: 416-426.
14. Onyeaso CO, Begole EA (2007) Relationship between index of complexity, outcome and need, dental aesthetic index, peer assessment rating index, and American Board of Orthodontics objective grading system. Am J Orthod Dentofacial Orthop 131: 248-252.
15. Song G, Jiang R, Zhang X, Liu S, Yu X, et al. (2015) Research group of establishing Chinese evaluation standard of orthodontic treatment outcome. [Validation of subjective and objective evaluation methods for orthodontic treatment outcome]. Beijing Da Xue Xue Bao 47: 90-97.
16. Houston WJB (1983) The analysis of errors in orthodontic measurements. Am J Orthod 83: 382-390.
17. Deguchi T, Terao F, Aonuma T, Kataoka T, Sugawara Y, et al. (2015) Outcome assessment of lingual and labial appliances compared with cephalometric analysis, peer assessment rating, and objective grading system in Angle Class II extraction cases. Angle Orthod 85: 400-407.
18. 3M (2012) Incognito Appliance System Treatment guide. The secret behind a beautiful smile. 3M Unitek 3: 1-8.
19. Lawson R (2013) Extraction treatment in lingual orthodontics. J Orthod 40: s38-48.
20. Mavreas D, Athanasio AE (2008) Factors affecting the duration of orthodontic treatment: a systematic review. Eur J Orthod 30: 386-395.