Original Article

A prospective randomized split-mouth study on pain experience during chairside archwire manipulation in self-ligating and conventional brackets

Michael H. Bertl[a]; Kanji Onodera[b]; Aleš G. Čelar[c]

ABSTRACT

Objective: To investigate patient discomfort during archwire engagement and disengagement in patients treated with self-ligating and conventional brackets using a split-mouth design.

Materials and Methods: Eighteen consecutive patients (15 female, 3 male; age: 22.2 ± 6.4 years) who requested treatment with fixed orthodontic appliances were randomly assigned for bonding with SmartClip self-ligating brackets on one side of the dentition and conventional standard edgewise brackets on the other. During the course of treatment, patients rated the discomfort experienced during every archwire engagement and disengagement using a numeric rating scale. Results were evaluated for round and rectangular nickel titanium and rectangular stainless steel, titanium molybdenum, and Elgiloy archwires. Patients also rated their overall experience retrospectively for both bracket systems.

Results: Regardless of archwire type, disengagement was rated as being significantly more painful on the SmartClip side ($P = .027$). For rigid, rectangular archwires, engagement and disengagement were rated as being significantly more painful on the SmartClip side ($P = .031$; $P = .004$). Retrospective ratings favored conventional brackets beyond ratings recorded during treatment.

Conclusion: Engagement and disengagement of rigid rectangular archwires caused more pain with SmartClip self-ligating brackets than with conventional ones. Careful archwire manipulation and patience during full alignment are essential for limiting chairside pain. Low pain levels will help ensure treatment satisfaction and compliance. (*Angle Orthod.* 2013;83:292–297.)

KEY WORDS: Self-ligating; Pain; Split-mouth

INTRODUCTION

Anticipation and experience of pain are a major deterrent to commencing orthodontic treatment and may result in deteriorating compliance and discontinuation of treatment.[1,2] Patients must expect initial pain within hours after archwire manipulation, a peak at 24 hours, and a notable decrease after 3 days.[3]

Bracket manufacturers promote patient comfort as an advantage of self-ligating brackets in spite of the controversy in the literature on this issue: more constant pain for conventional ligation[4] and no influence of bracket type on overall pain experience[5] have been reported. Two prospective, randomized clinical trials showed either significantly lower maximum and mean pain intensities[6] or no differences[7] for the same type of self-ligating bracket compared with a conventional bracket. Individual variation and subjectivity in pain experience[8,9] may explain inconsistent findings in the literature, especially when bracket systems are compared across different patients.

Burstone[10] described two types of pain during treatment with fixed orthodontic appliances: an immediate type, which was associated with sudden, heavy forces applied to teeth as experienced during chairside manipulation of the appliance, and a delayed type, which resulted from hyperalgesia of the periodontal membrane. Although the latter type was extensively studied

[a] Resident, Division of Orthodontics, Bernhard Gottlieb University Clinic of Dentistry, Medical University of Vienna, Vienna, Austria.

[b] Resident, Department of Craniofacial Growth and Developmental Dentistry, Kanagawa Dental College, Yokosuka, Kanagawa, Japan.

[c] Professor, Division of Orthodontics, Bernhard Gottlieb University Clinic of Dentistry, Medical University of Vienna, Vienna, Austria.

Corresponding author: Michael H. Bertl, Division of Orthodontics, Bernhard Gottlieb University Clinic of Dentistry, Medical University of Vienna, Sensengasse 2a, 1090 Vienna, Austria (e-mail: michael.bertl@meduniwien.ac.at)

Accepted: June 2012. Submitted: April 2012.
Published Online: July 24, 2012

 DOI: 10.2319/042312-338.1

in connection with self-ligating brackets,[4–7] certain self-ligating brackets also caused immediate discomfort during archwire engagement and disengagement.[5] Although changing the archwire constitutes only a fraction of the entire treatment time, patients perceive pain in the presence of the treating orthodontist, and this experience may have a disproportionally high influence on patients' overall comfort and satisfaction with treatment.

The aim of this study was to investigate the potential difference in pain experience during archwire engagement and disengagement in patients treated simultaneously with self-ligating and conventional brackets, and to account for individual perception of pain by applying a split-mouth design.

MATERIALS AND METHODS

This study was independently reviewed and approved by the ethical board of the Medical University of Vienna (No. 536/2006). Based on sample-size calculation, consecutive patients were recruited before the start of their respective orthodontic treatment. Inclusion criteria encompassed an orthodontic treatment plan with fixed appliances in both arches and lack of apparent dental arch asymmetries. To confirm symmetry, unilateral irregularity indices were calculated by measuring the linear displacement of the adjacent anatomic contact points between the central and lateral incisors and the lateral incisors and canines on the initial casts.[11] Additionally, we assessed the symmetry of the lateral segments by measuring the distances between the canine cusp tip and buccal cusp tip of the first premolar, first premolar to second premolar buccal cusp tips, and second premolar buccal cusp tip to first molar mesiobuccal cusp tip in all four quadrants.

All patients were treated nonextraction by the same clinician (KO) for the vast majority of appointments. He used a split-mouth design with random assignment of self-ligating brackets (SmartClip, 3M Unitek Orthodontic Products, Monrovia, Calif) on one side of the dentition and conventional standard edgewise brackets (American Orthodontics, Sheboygan, Wis) on the other side. Assignment of bracket type and side was determined by drawing lots. Stainless steel ligatures (0.01″) secured the archwires in the conventional brackets, and pressure to the slot-aligned archwire engaged them in the self-ligating brackets. Archwires were disengaged by cutting the ligatures or by using the manufacturer-recommended instrument (SmartClip Appliance Wire Disengagement Hand Instrument, 3M Unitek Orthodontic Products), which provided a reciprocal force against the bracket while pulling the archwire out of the slot. During this manipulation, patients were asked to bite on a cotton roll, markedly compressing it to about half its original diameter. Patients were first instructed which side had been bonded with self-ligating or conventional brackets.

After initial bonding and on every consecutive appointment entailing the engagement and/or disengagement of archwires, patients rated the discomfort experienced during either procedure for both sides using a numeric rating scale (NRS) at the end of the respective appointment. The NRS ranged from 0 (no pain) to 10 (most severe pain imaginable).

All scores related to one of the following treatment procedures: engaging round nickel titanium (NiTi) archwires (0.016″); disengaging round NiTi archwires; engaging rectangular NiTi archwires (0.014 × 0.025″); disengaging rectangular NiTi archwires; engaging rectangular stainless steel (SS; 0.018 × 0.025″), titanium molybdenum alloy (TMA; 0.017 × 0.025″), or CoCr (Blue Elgiloy; 0.016 × 0.022″) archwires; and disengaging rectangular SS, TMA, or CoCr archwires. At the end of treatment, the patients also rated their overall experience retrospectively for both bracket systems on the same type of NRS.

Statistics

Sample size was calculated based on effect sizes derived from the previous literature,[5] α of 0.05, a power of 0.8 and by adding 20% to account for possible dropouts. Paired *t*-tests were used to compare the unilateral irregularity indices and intercanine distances between the SmartClip and conventional sides. Differences between NRS scores were calculated for each instance of archwire engagement or disengagement by subtracting the conventional bracket score from the SmartClip score, thus favoring conventional brackets in case of positive outcomes and SmartClip brackets in case of negative outcomes. In the case of multiple results for the same treatment procedure within one patient (ie, reengagement of the same archwire or engagement of the same type of archwire of larger dimensions), mean values were used in further analysis. Normal distributions were verified by Kolmogorov-Smirnov tests. A paired *t*-test was used for irregularity indices and one-sample *t*-tests against the test value 0 for NRS differences (ie, no difference between the SmartClip and the conventional side). Repeated measures analysis of variance compared treatment phases and included Bonferroni corrections for multiple testings. *P* values $<.05$ were considered statistically significant. Applied software packages were SPSS Statistics 20 (SPSS Inc, Chicago, Ill), DataGraph 3.0 (Visual Data Tools Inc, Chapel Hill, NC) and G*Power 3.1.3.[12]

Table 1. Unilateral Irregularity indices and Intercuspid Distances on (mm) Initial Casts

	SmartClip Side		Conventional Side		
	Mean	SD	Mean	SD	*P*-Value
Irregularity index, maxillary	3.1	2.1	3.1	2.6	.858
Irregularity index, mandibular	2.7	1.2	3.0	1.2	.404
Intercuspid distance 3–4, maxillary	8.7	0.9	8.4	1.1	.063
Intercuspid distance 4–5, mandibular	7.3	0.3	7.3	0.4	.352
Intercuspid distance 5–6, maxillary	6.9	0.5	6.9	0.6	.875
Intercuspid distance 3–4, mandibular	7.1	0.7	7.4	0.7	.079
Intercuspid distance 4–5, maxillary	7.5	0.6	7.6	0.5	.472
Intercuspid distance 5–6, mandibular	7.1	0.7	7.1	0.7	.961

RESULTS

Sample and Cast Analysis

The effect size d was calculated at 0.98 for archwire removal and 0.79 for insertion. Sample size was therefore determined at 15 based on the smaller effect size and 20% added to account for possible dropouts. The recruited sample of 18 consisted of 15 female and 3 male patients with a mean age of 22.2 ± 6.4 years. Eleven patients received self-ligating brackets on the left side and seven on the right. Mean unilateral irregularity indices and inter-canine distances are shown in Table 1. Indices and distances did not differ significantly between the conventional and self-ligating brackets sides (Table 1). Starting from mesial, the means of the absolute differences between left and right inter-canine distances were 0.5 ± 0.4, 0.2 ± 0.2, and 0.4 ± 0.4 mm in the maxillary arch and 0.6 ± 0.5, 0.3 ± 0.3, and 0.4 ± 0.3 mm in the mandibular arch.

Archwire Engagement

The accumulated NRS score differences recorded during treatment favored conventional brackets nonsignificantly ($P = .21$). Although the engagement of rectangular SS, TMA, and CoCr archwires was rated as being significantly more painful on the self-ligating bracket side ($P = .031$) (Table 2), there were no significant differences between the wire types (Figure 1).

Archwire Disengagement

Patients rated archwire disengagements as being significantly more painful on the self-ligating bracket side ($P = .027$). The disengagement of rectangular SS, TMA, and CoCr archwires showed a significant difference between the two bracket types ($P = .004$), favoring conventional brackets (Table 2). The NRS score difference for those rigid wire types was also significantly higher than for rectangular NiTi archwires ($P = .017$) (Figure 2).

Retrospective Results

The retrospective rating differences exceeded those recorded during treatment for both archwire engagement and disengagement, and they favored conventional brackets nonsignificantly ($P = .485$; $P = .239$) (Figures 1 and 2; Table 2).

DISCUSSION

In regards to individual differences in the perception of pain,[8,9] the present study used a split-mouth design to investigate patient discomfort during chairside archwire manipulation in self-ligating and conventional brackets. Regardless of archwire type, the patients only rated disengagement as being significantly more painful on the side bonded with self-ligating brackets, whereas engagement and disengagement of rectangular SS, TMA, and CoCr archwires caused more pain on the self-ligating bracket side.

Table 2. Differences in Numeric Rating Scale Scores (SmartClip Minus Conventional) for Engagement and Disengagement of Archwires[a]

	Archwire Engagement					Archwire Disengagement				
	Mean	SD	95% CI		*P*-Value*	Mean	SD	95% CI		*P*-Value*
NiTi rnd	−0.50	1.51	−1.76	0.76	.381	−0.50	2.12	−2.13	1.13	.500
NiTi rect	−0.13	2.71	−2.39	2.14	.900	0.57	1.48	−0.37	1.51	.209
SS/TMA/CoCr	1.22	2.19	0.13	2.30	.031	1.45	1.80	0.52	2.38	.004
Accumulated	0.97	2.25	−0.15	2.08	.085	1.04	1.87	0.10	1.97	.032
Retrospective	1.55	2.63	−0.33	3.43	.095	1.60	3.27	−0.74	3.94	.157

[a] NiTi rnd indicates round nickel titanium archwires; NiTi rect, rectangular nickel titanium archwires; and SS/TMA/CoCr, stainless steel, titanium molybdenum alloy, or Elgiloy blue archwires.

* *P*-values of one-sample *t*-tests against the test value 0.

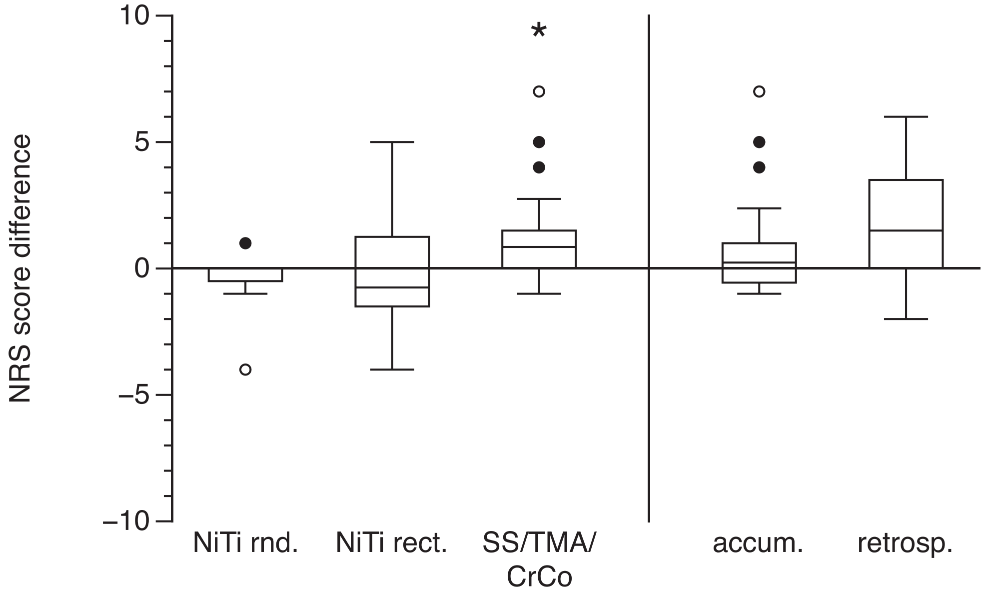

Figure 1. Differences in numeric rating scale scores (SmartClip minus conventional) for the engagement of round nickel titanium (NiTi rnd.); rectangular nickel titanium (NiTi rect.); and stainless steel (SS), titanium molybdenum alloy (TMA), or Blue Elgiloy (CoCr) archwires. Accumulated treatment (accum.) and retrospective (retrosp.) score differences (*$P < .05$).

Manipulation of full-size archwires was previously shown to cause more pain in self-ligating brackets than in conventional brackets.[5] Fleming et al.[5] mainly focused on pain during initial alignment; chairside manipulation was only evaluated for the removal of 0.019 × 0.025″ NiTi and insertion of 0.019 × 0.025″ SS archwires. Both procedures were rated as being more painful in self-ligating brackets. Their results are in accordance with those of rigid, rectangular archwires in the present investigation. In a split-mouth designed study, Damon 2 self-ligating brackets did not cause additional discomfort during initial leveling.[13] However, the use of rectangular stainless steel archwires was also rated as being more painful, quoting greater residual malalignment as a possible cause.[13] Considerable differences in the design and mechanism of archwire engagement complicate comparisons of various types of self-ligating brackets.[14] Most systems require pressure to the archwire for engagement. The pressure rises with increasing archwire

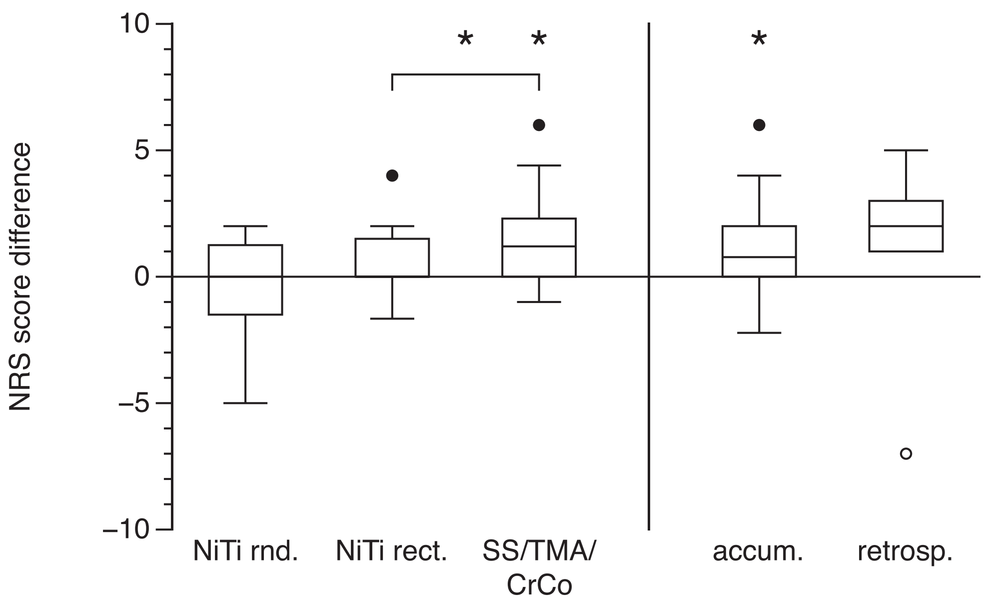

Figure 2. Differences in numeric rating scale scores (SmartClip minus conventional) for the disengagement of round nickel titanium (NiTi rnd.); rectangular nickel titanium (NiTi rect.); and stainless steel (SS), titanium molybdenum alloy (TMA), or Blue Elgiloy (CoCr) archwires. Accumulated treatment (accum.) and retrospective (retrosp.) score differences (* $P < .05$).

rigidity and dimension, and it depends on the present level of tooth alignment. Because chairside pain experience is a result of tooth displacement caused by the force necessary to close the engagement mechanism, manipulation of rigid and full-size archwires can be associated with more discomfort in self-ligating brackets. If elastic ligatures are used on conventional brackets, full engagement is not always achieved. In the present investigation, SS ligatures were used to maximize and therefore match the level of engagement in both systems.

The funnel-shaped retentive clip in self-ligating brackets (SmartClip) facilitates archwire insertion. Archwire removal requires considerable force, which creates opposite tooth displacement. The nature of this clip may therefore account for the more unfavorable ratings on archwire removal in self-ligating brackets, which was also reported by Fleming et al.[5] To limit excessive tooth displacement during archwire manipulation, patients should be advised to bite on cotton rolls. So-called bite wafers reduced pain in the hours and days after archwire placement.[15,16] If also used during archwire manipulation, the viscoelasticity and arch-shaped form of the wafers may limit tooth displacement even more effectively than cotton rolls.

Because pain response to orthodontic treatment is largely unrelated to the dental arch, crowding, gender, or social class,[17] a pretreatment identification of pain-sensitive patients and consequent avoidance of a particular bracket type seems implausible. In regard to patient comfort throughout treatment, practitioners should remember that patient memories of medical procedures typically reflect the pain intensity at the worst and later part of the experience.[18] In the present study the retrospective ratings also exceeded those recorded during treatment and aligned with the final and most painful treatment phase (ie, engagement and disengagement of rigid and rectangular archwires in self-ligating brackets). Consequently patients should be made aware of the severity of their malocclusion at the onset of treatment. This instruction can help manage the perception of discomfort.[19] Later on, avoiding peaks of pain can positively influence nociceptive memories,[18] even if the use of cotton rolls or bite wafers means more expenditure in time and materials.

Pain from orthodontic treatment should be considered beyond the obvious incentive to avoid patient discomfort. The patient's attitude toward treatment and compliance is predictable from the amount of pain experienced.[19,20] The correlation between patient discomfort, appliance acceptance, and good treatment cooperation[1] relates to the interests of patient and practitioner alike. Additionally, the pain-related release of neuropeptides and their potential influence on the biological mechanisms of orthodontic tooth movement may prove worthy subjects of further research.[21]

Because the use of self-ligating brackets in orthodontic practices will continue, measures should be taken to counteract the shortcomings of these brackets. The preemptive analgesia with nonsteroidal anti-inflammatory drugs represents one option for the remedy of pain.[22,23] The alternative is limiting excessive horizontal tooth displacement during manipulation of rigid archwires and avoiding their premature use in unaligned dental arches.

Which limitations applied to the present study? The sample size was calculated based on data on removal and insertion of $0.019 \times 0.025''$ archwires,[5] which may not have accounted for smaller effective differences in archwires of lesser dimensions. Also, the presented results are particular to the SmartClip bracket and cannot be generalized to other self-ligating systems with different designs. Similar studies have been performed on larger samples.[5,13] However the split-mouth design of the present study arguably provided a better control, though it required a rigorous recruitment regarding dental arch asymmetries and patients' acceptance of an esthetic compromise during treatment, resulting from the uneven bracket appearance. Large confidence intervals (CIs) applied to all data presented, but in all significant results CIs ranged above the testing value of 0, where 0 indicated no difference between bracket types (Table 2). Although patients were not specifically instructed about the side bonded with self-ligating brackets, visible differences in their design prevented proper blinding in this type of investigation.

CONCLUSIONS

- Within the aforementioned limitations, engagement and disengagement of rigid, rectangular archwires in SmartClip self-ligating brackets were rated as being more painful than in conventional brackets.
- Careful manipulations, use of cotton rolls or bite wafers, and patience with the effects of orthodontic archwires in aligning teeth are essential for limiting chairside pain. This approach will help ensure treatment satisfaction and continuing compliance, particularly with the SmartClip bracket system and its unique design properties.

ACKNOWLEDGMENT

The authors kindly thank Professor Dr Hans-Peter Bantleon for initiating this study and report no conflict of interest regarding its execution.

REFERENCES

1. Doll GM, Zentner A, Klages U, Sergl HG. Relationship between patient discomfort, appliance acceptance and compliance in orthodontic therapy. *J Orofac Orthop*. 2000; 61:398–413.
2. Krishnan V. Orthodontic pain: from causes to management—a review. *Eur J Orthod*. 2007;29:170–179.
3. Erdinc AM, Dincer B. Perception of pain during orthodontic treatment with fixed appliances. *Eur J Orthod*. 2004;26:79–85.
4. Tecco S, D'Attilio M, Tete S, Festa F. Prevalence and type of pain during conventional and self-ligating orthodontic treatment. *Eur J Orthod*. 2009;31:380–384.
5. Fleming PS, Dibiase AT, Sarri G, Lee RT. Pain experience during initial alignment with a self-ligating and a conventional fixed orthodontic appliance system. A randomized controlled clinical trial. *Angle Orthod*. 2009;79:46–50.
6. Pringle AM, Petrie A, Cunningham SJ, McKnight M. Prospective randomized clinical trial to compare pain levels associated with 2 orthodontic fixed bracket systems. *Am J Orthod Dentofacial Orthop*. 2009;136:160–167.
7. Scott P, Sherriff M, Dibiase AT, Cobourne MT. Perception of discomfort during initial orthodontic tooth alignment using a self-ligating or conventional bracket system: a randomized clinical trial. *Eur J Orthod*. 2008;30:227–232.
8. Ngan P, Kess B, Wilson S. Perception of discomfort by patients undergoing orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 1989;96:47–53.
9. Wright N, Modarai F, Cobourne MT, Dibiase AT. Do you do Damon®? What is the current evidence base underlying the philosophy of this appliance system? *J Orthod*. 2011;38: 222–230.
10. Burstone CJ. The biomechanics of tooth movement. *Vistas in Orthodontics*. Philadelphia, Pa: Lea & Febiger: 1962; 197–213.
11. Little RM. The irregularity index: a quantitative score of mandibular anterior alignment. *Am J Orthod*. 1975;68: 554–563.
12. Faul F, Erdfelder E, Lang AG, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*. 2007;39:175–191.
13. Miles PG, Weyant RJ, Rustveld L. A clinical trial of Damon 2 vs conventional twin brackets during initial alignment. *Angle Orthod*. 2006;76:480–485.
14. Fleming PS, Johal A. Self-ligating brackets in orthodontics. A systematic review. *Angle Orthod*. 2010;80:575–584.
15. Farzanegan F, Zebarjad SM, Alizadeh S, Ahrari F. Pain reduction after initial archwire placement in orthodontic patients: a randomized clinical trial. *Am J Orthod Dentofacial Orthop*. 2012;141:169–173.
16. Murdock S, Phillips C, Khondker Z, Hershey HG. Treatment of pain after initial archwire placement: a noninferiority randomized clinical trial comparing over-the-counter analgesics and bite-wafer use. *Am J Orthod Dentofacial Orthop*. 2010;137:316–323.
17. Jones M, Chan C. The pain and discomfort experienced during orthodontic treatment: a randomized controlled clinical trial of two initial aligning arch wires. *Am J Orthod Dentofacial Orthop*. 1992;102:373–381.
18. Redelmeier DA, Kahneman D. Patients' memories of painful medical treatments: real-time and retrospective evaluations of two minimally invasive procedures. *Pain*. 1996;66:3–8.
19. Sergl HG, Klages U, Zentner A. Pain and discomfort during orthodontic treatment: causative factors and effects on compliance. *Am J Orthod Dentofacial Orthop*. 1998;114: 684–691.
20. Sergl HG, Klages U, Zentner A. Functional and social discomfort during orthodontic treatment—effects on compliance and prediction of patients' adaptation by personality variables. *Eur J Orthod*. 2000;22:307–315.
21. Yamaguchi M, Takizawa T, Nakajima R, Imamura R, Kasai K. The Damon System and release of substance P in gingival crevicular fluid during orthodontic tooth movement in adults. *World J Orthod*. 2009;10:141–146.
22. Young AN, Taylor RW, Taylor SE, Linnebur SA, Buschang PH. Evaluation of preemptive valdecoxib therapy on initial archwire placement discomfort in adults. *Angle Orthod*. 2006;76:251–259.
23. Xiaoting L, Yin T, Yangxi C. Interventions for pain during fixed orthodontic appliance therapy. A systematic review. *Angle Orthod*. 2010;80:925–932.