Retention efficacy and patient experience with customized clear retainer and wrap-around circumferential retainer among non-extraction orthodontic patients

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감사의 글

먼저, 저를 지금의 교정과전문의로 성장할 수 있도록 교육해주시고 박사 연구와 논문 작성을 지도해주신 최성환 교수님께 진심으로 감사드립니다. 레지던트 시절부터 교정진료를 가르쳐주심은 물론, 치과의사로서의 올바른 마음가짐을 갖게 해주신 유형석 교수님께도 진심으로 감사드립니다. 또한 이 연구를 진행할 수 있는 기회를 주시고, 연구책임자로서 많은 조언과 도움을 아끼지 않으신 이기준 교수님께 깊이 감사드립니다. 훌륭한 논문이 완성될 수 있도록 연구의 설계부터 논문 작성 및 수정을 도와주신 망갈 교수님께 또한 감사드립니다. 마지막으로 바쁘신 와중에도 소중한 시간을 내어 조언해주신 차정열 교수님께도 깊은 감사의 말씀을 전합니다.

연세대학교 치과교정학교실의 일원이 되어 공부할 수 있는 기회를 주시고 올바른 의술을 펼칠 수 있도록 지도해 주신 황충주 교수님, 김경호 교수님, 정주령 교수님, 최윤정 교수님, 박선형 교수님, 이지현 교수님, 최재훈 교수님, 김하림 교수님께도 깊이 감사드립니다.

또한 이 연구를 진행하는 동안 여러 방면으로 도움을 주신 유재훈 선생님, 김하나 선생님께도 감사의 마음을 전합니다.

3 년의 수련기간 동고동락하며 성장한 교정과 의국 동기들과 더불어 진료 및 의국 생활에 잘 적응할 수 있도록 도와준 의국 선배님들, 그리고 든든한 의국 후배님들께도 감사의 마음을 전하고 싶습니다.

마지막으로 제가 이 길을 걷게 된 가장 큰 이유와 영감을 주신 아버지, 항상 제 편이 되어주시는 어머니께도 감사의 마음을 전합니다. 치과의사라는 같은 길을 걷는 대견한 남동생과 먼 타국에서 대학생으로서 유학생활을 꿋꿋히 훌륭하게 해내고 있는 여동생에게도 고마운 마음을 전합니다. 지면에 미처 언급하지 못했으나 저에게 많은 격려와 응원해주신 모든 분께도 다시 한번 감사하다는 말씀을 전합니다.

2025 년 7 월 저자 씀

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ABSTRACT

Retention efficacy and patient experience with customized clear retainer and wrap-around circumferential retainer among non-extraction orthodontic patients

The selection of the type of removable retainer following orthodontic treatment has long remained an uncertain and contentious issue, primarily due to insufficient evidence concerning their retention efficacy and patient compliance. The aim of this study was to evaluate retention efficacy by assessing retention stability and patient perspectives according to type of circumferential retainer: the wrap-around circumferential retainer (WCR) and customized clear retainer (CCR).

This cohort follow-up study involved 52 patients aged 18–62 who underwent fixed-appliance orthodontic treatment without extractions or orthognathic surgery. Following screening consenting participants were divided into WCR and CCR groups. All participants before follow-up received fixed retainers for the upper and lower anteriors and respective removable retainers within two weeks post-debond. Intraoral scans and lateral cephalograms were taken immediately after debonding (T0) and again 12 months later. Dentoalveolar changes in several measurements were compared to evaluate retention efficacy. Surveys were conducted at 1 month (T1) and 12 months (T2) post-debonding to assess changes in patient experiences. Outcome assessments were blinded. Paired T-tests and independent T-tests were used for intragroup and intergroup comparisons of dentoalveolar measurements, respectively. Survey responses were analyzed using the Pearson Chi-Square test.

The final assessment included 32 participants. Model analysis revealed no significant differences between the groups, except for maxillary intermolar width (P = .033). In the WCR group, cephalometric analysis indicated a significant increase in the incisor mandibular plane angle (P = .002) and a decrease in the interincisal angle (P = .014), while changes in the CCR group were statistically non-significant. Patient attitude evaluation showed similar trends for wear time and overall satisfaction. However, a higher percentage of respondents in the WCR group reported irritation when wearing the retainers (P = .037) at T1 and discomfort related to speech (P = .038) at T2.

This study revealed that CCR showed better retention efficacy in terms of lower incisor inclination and patients experienced relatively less irritation and speech discomfort with CCRs.

Key words: Customized clear retainer, Wrap-around retainer, Randomized clinical trial, Retention, Orthodontic Retainers, Effectiveness, Patient experience

1. Introduction

It is a common practice and protocol to prescribe a full-time retention appliance upon completion of active orthodontic treatment. Retention protocols in orthodontic treatment has always been challenging and controversial, due to epidemiological variations influenced by difference in protocols and patients' direct perception during retainer use (Padmos, Fudalej, and Renkema 2018). Recent studies on retention protocols primarily compare bonded cuspid-to-cuspid fixed retainers with removable retainers (Bellini-Pereira et al. 2022; Krämer et al. 2021; O'Rourke et al. 2016). However, conclusions drawn over the short term often indicate no significant difference in retention stability with the fixed retainer (Forde et al. 2018; Naraghi et al. 2021).

On average, wearing removable dental retainers is advised for about 2 years, though individual needs can extend or shorten this time by up to 1.6 years (Padmos, Fudalej, and Renkema 2018). For the retainers to work effectively, it's vital they are worn continuously, especially at the start. Comfort is a key factor, as it influences whether patients will wear them as required. Among the commonly prescribed retainer types—Hawley, wrap-around circumferential (WCR), and customized clear retainer (CCR)—patient compliance often depends on how the retainers affect speech and their appearance. Notably, these designs vary in palatal coverage, with Hawley retainers having full palatal coverage, WCRs have minimal extension whereas CCRs have no palatal extension, leading to higher acceptance of CCRs over Hawley retainers (Patnaik, Nanda, and Mishra 2023; Saleh, Hajeer, and Muessig 2017).

Another concern during retention phase is of occlusal settling and interdigitation. It is an essential factor in achieving a long-term stable occlusion. Tooth-retainer contact brings characteristic changes in tooth movements during the use (Alkan and Kaya 2020). While WCRs facilitate initial settling, CCRs have been suggested to restrict occlusal settling (English et al. 2014). Additionally, the natural evolution of occlusal surface area and contact points during long-term retention plays a role in guiding posterior settling (Alkan and Kaya 2020). The use of CCRs in both the maxillary and mandibular arches introduces a double-thickness plastic layer between the posterior occlusion surfaces, sparking debate regarding the influence of CCRs on settling (Alkan, Kaya, and Keskin 2020; Dinçer and Işık Aslan 2010).

Therefore, considering factors such as comfort, compliance, esthetics, and occlusal stability, it becomes imperative to conduct a comprehensive study on the efficacy of retention with extended follow-up periods. However, there is a shortage of evidence-based research reporting measurable outcomes of various retention methods. Specifically, regarding removable retainers, there is a lack of comprehensive evidence analyzing the stability of dentition while considering patients' perspectives. Although clinical practice guidelines have been published, there remains a lack of literature showing outcomes that correspond with these guidelines to date (Wouters et al. 2019).

In light of these considerations, a prospective cohort follow-up study was conducted to evaluate the retention capacity of two types of removable retainers: WCR and CCR (Vivera® retainers, Align Technology, San Jose, CA) (Figure 1). The study comprehensively analyzed changes in dental and cephalometric parameters over a 1-year follow period following active orthodontic treatment. In addition, a detailed analysis of patients' attitudes and preferences regarding the retainers was conducted using questionnaires designed to assess compliance, discomfort, and satisfaction. The null hypothesis was formulated to assert that there would be no significant difference in retention efficiency, which refers to both the stability of tooth position over time and the level of patient compliance, between WCR and CCR retainers.

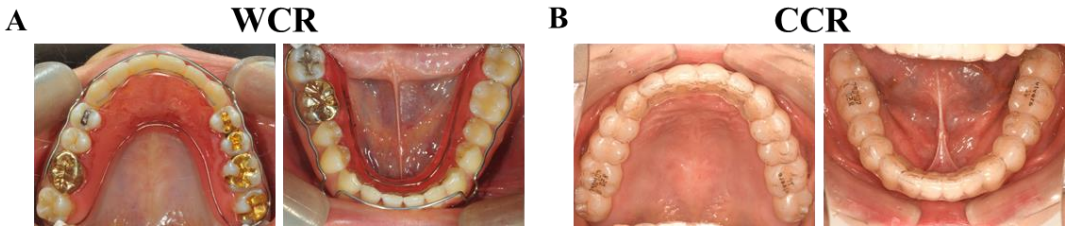

Figure 1. Intraoral photographs of the removable and bonded lingual retainers.
A, wrap-around circumferential retainer (WCR); B, customized clear retainer (CCR).

2. Materials and methods

2.1. Study design

The prospective cohort follow-up study was performed with ethical approval from the Institutional Review Board of Yonsei University Dental Hospital (2-2021-0030).

2.2. Participants, eligibility criteria, and settings

Patients were recruited from the Department of Orthodontics at Yonsei University Dental Hospital, Seoul, Republic of Korea, between June 2021 and July 2022. The selection criteria followed were as follows:

2.2.1. Inclusion criteria

Adult patients aged 18 years and older, non-extraction fixed orthodontic treatment, presence of complete dentition except for the third molars, fixed retainers attached to both the upper and lower anterior teeth, and achievement of planned functional occlusion.

2.2.2. Exclusion criteria

Patients who had undergone orthognathic surgery, presence of a high decayed, missing, filled teeth index or malformed teeth, refusal of fixed retainer placement, presence of facial asymmetry, history or presence of temporomandibular joint symptoms, and history of periodontal disease. There were no modifications to the methods after the commencement of the trial.

2.2.3. Screening and allocation

All participants meeting the inclusion criteria were screened during their appointment immediately prior to debonding. Detailed information regarding the study was provided both verbally and in written form to the patients, and their written consent was subsequently obtained. All participant before study commencement received bonded fixed retainers (Titainer, Lingualign Corp, Pohang, Korea) on both upper and lower incisors (from canine to canine) just before the debonding procedure (Kang et al. 2022). Participants were stratified into two groups based on the retainer type they had received. WCR group participants had wrap-around circumferential retainers having acrylic base plate with a 0.7-mm diameter stainless steel wire running along the labial and buccal surfaces of the entire dentition, including the second molar. The CCR group participants had

customized clear Vivera® retainers manufactured by Align Technology, San Jose, CA. Screening, and allocation were done by an independent orthodontist (JHB). All orthodontic treatment and retainer delivery was done by two experienced orthodontists (KJL, SHC).

During the initial month of retention, patients were advised to wear both the maxillary and mandibular retainers continuously, 24 hours a day, excluding periods of eating and brushing. After the first month, the recommended wearing time was adjusted to exceed eight hours daily, inclusive of sleeping hours.

2.3. Follow-up

For baseline data, immediately following the removal of fixed appliances (T0), intraoral scans and lateral cephalometric radiographs (PaX-i3D Smart; Vatech Co., Gyeonggi-Do, Korea) were conducted for all patients in both groups using the iTero HD 2.9 intra-oral scanner (Align Technology, San Jose, CA). The follow-up data collections occurred one month (T1) and one year (T2) after debonding, during which participants completed questionnaires. Additionally, intraoral scan data and lateral cephalometric radiographs were collected at T2. The retainer control appointments were scheduled between T1 and T2 study time-points to ensure the any issues with the removable and bonded lingual retainer could be addressed. All participants were also instructed to seek immediate replacement for any inadvertent loss or breakage.

2.4. Outcome assessment

The retention stability was assessed by examining dentoalveolar changes over a one-year retention period. These changes were measured using intraoral scans and lateral cephalograms by a single investigator (JHB). The intraoral scans provided data on overjet, overbite, and the widths of the intercanine and intermolar areas in both the maxilla and mandible. These measurements were conducted using Alignstudio software (Laon Medi Co., Gyeonggi-Do, Korea) (Yu et al. 2023). Lateral cephalograms facilitated the measurement of five indicators related to the position and angle of incisors (Upper incisor to palatal plane (U1 to PP, mm), incisor mandibular plane angle (IMPA; degree), Upper incisor to SN plane angle (U1-SN; degree), lower incisor to mandibular plane angle (L1 to MP; degree), and the interincisal angle (degree), two indicators for molar position (upper first molar to palatal plane (U6 to PP; mm), lower first molar to mandibular plane (L6 to MP; mm), and the angle of the occlusal plane relative to the SN plane, to assess the degree of relapse.

The secondary outcome involved assessing patient compliance with two types of retainers at one month (T1) and twelve months (T2) post-debonding, utilizing a questionnaire specifically

designed for this study. This questionnaire comprised three sections with a total of nine questions, covering the following areas: patient cooperation, discomfort experienced, and overall satisfaction.

2.5. Sample size calculation

An a priori power analysis was conducted using GPower 3.1 (University of Düsseldorf, Germany) to determine the necessary minimum sample size. This analysis aimed to detect an effect size of 0.5, with a significance level set at $\alpha = 0.05$ and a power of $1-\beta = 0.9$ (Edman Tynelius et al. 2015) According to the results, at least 22 patients per group, amounting to a total of 44 patients, were required. To accommodate potential loss to follow-up, 60 patients were initially screened for eligibility.

2.6. Statistical analysis

Descriptive statistics, including means and standard deviations, were utilized to summarize all angular and linear variables. The normal distribution of these variables was confirmed using the Kolmogorov-Smirnov test. For assessing changes within groups over time, paired T-tests were employed, while independent T-tests were used for comparisons between groups. Questionnaire responses regarding patient compliance were analyzed, with the Pearson Chi Square test setting the threshold for statistical significance at $P < 0.05$. Method error analysis was conducted by a single assessor (JHB) who repeated all measurements after at least 2 weeks and tested against Bland–Altman analysis. Paired T-tests showed no significant differences or bias, and the absolute mean measurement errors were reported. All statistical analyses were conducted using IBM SPSS software for Windows, version 25.0 (IBM, Armonk, NY).

3. Results

3.1. Participant flow

In enrollment (from June 2021 to July 2022), 52 patients were selected to take part in this study. Among them, 20 patients (11 WCR, 9 CCRs) were lost during follow-up period or did not make it to the last T2 appointment. As a result, a total of 32 patients (14 WCR, 18 CCRs) were included in the final analysis (Figure 2).

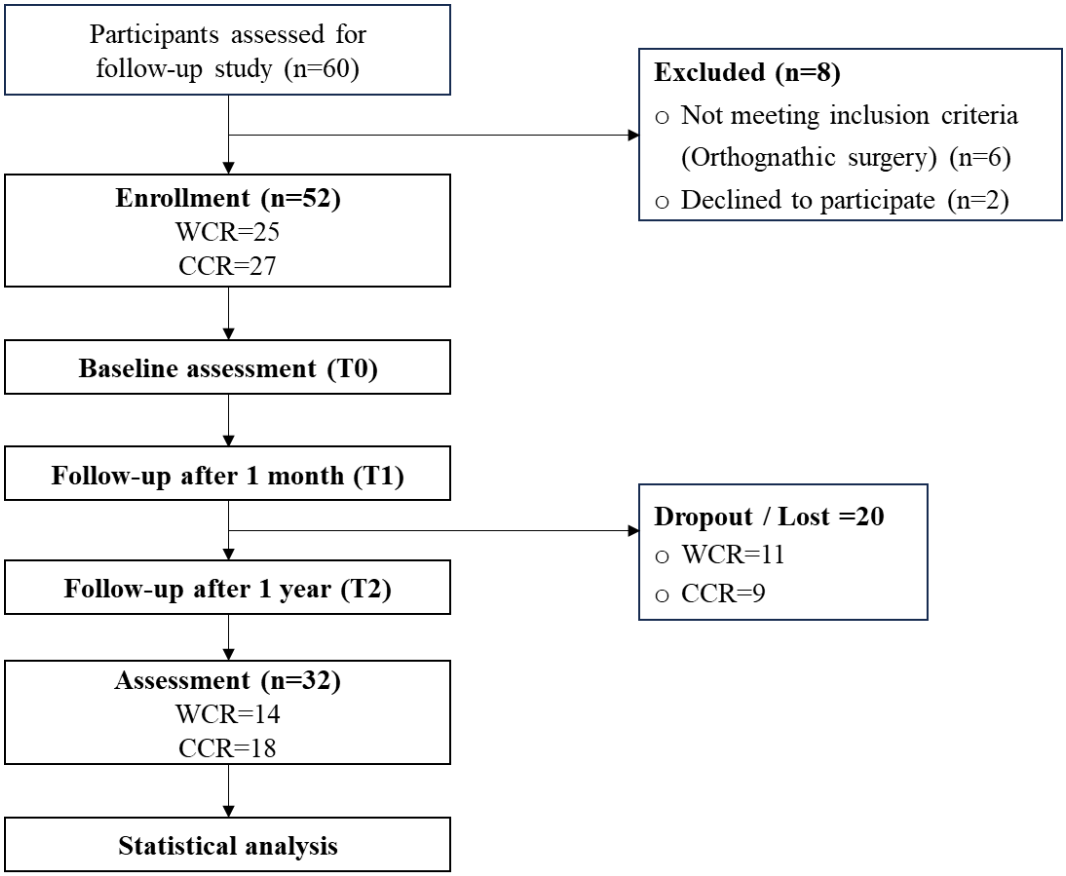

Figure 2. The flow diagram of participants in the follow-up study.

3.2. Baseline data

At baseline, information regarding age and sex was collected. Baseline characteristics were similar in both groups (Table 1).

Table 1. Baseline characteristics of the study participants allocated to wrap-around circumferential retainer (WCR) and customized clear retainer (CCR) groups

Variable	WCR (n=14)	CCR (n=18)	*P* value
Age, y			
Range	18 to 46	18 to 62	
Mean (SD)	25.93 (7.35)	24.67 (10.15)	0.319 [a]
Sex, n (%)			
Female	7 (50)	7 (38.9)	0.530 [b]
Male	7 (50)	11 (61.1)	
Retention, mo			
Range	9.63 to 12.37	10.20 to 13.97	0.359 [c]
Mean (SD)	11.16 (0.88)	11.47 (0.96)	

[a] *P* value was calculated using Mann-Whitney U-test.
[b] *P* value was calculated using chi-square test.
[c] *P* value was calculated using independent t-test

3.3. Retention stability after one-year follow-up

Table 2 presents the mean differences in measurements from scan model analyses between T0 and T2. During 1-year of retention, both WCR and CCR groups experienced a statistically significant ($P < 0.05$) decrease in overbite. There was no significant change observed in the maxillary transverse dimensions, specifically in the intercanine width for either group. However, the CCR group showed a significant increase in maxillary intermolar width at the one-year follow-up ($P = .046$). In contrast, the WCR group exhibited a significant decrease in mandibular intercanine width ($P = .040$). Intergroup comparisons indicated that all changes in measurements were nonsignificant, except for the maxillary intermolar width ($P = .033$). The absolute mean measurement errors for the intraoral scan measurements for overjet, overbite, and the widths of the intercanine and intermolar areas were 0.15, 0.10, 0.15, 0.33, 0.20, 0.30 mm respectively.

Table 2. Dentoalveolar measurement changes (mm) during 1 year of retention between two retainer groups.

Outcome Variable	WCR		CCR		Intergroup difference *P* value [b]
	Mean difference ± SD (T0-T2)	Intragroup difference *P* value [a]	Mean difference ± SD (T0-T2)	Intragroup difference *P* value [a]	
Overjet	-0.0 ± 0.2	.736	-0.1 ± 0.3	.064	.258
Overbite	-0.1 ± 0.2	.039*	-0.2 ± 0.4	.043*	.323
Maxilla					
Intercanine width	0.1 ± 0.6	.642	0.1 ± 0.3	.258	.940
Intermolar width	-0.1 ± 0.5	.315	0.3 ± 0.6	.046*	.033*
Mandible					
Intercanine width	-0.2 ± 0.3	.040*	-0.1 ± 0.8	.742	.259
Intermolar width	0.2 ± 0.4	.061	0.2 ± 0.5	.057	.966

[a] paired T-test; [b] independent T-test, * statistically significant result, WCR, wrap-around circumferential retainer; CCR, customized clear retainer.

The analysis of lateral cephalograms showed that the use of CCR led to no significant changes in any measurements during the one-year retention period (Table 3). On the other hand, in the group using the WCR, there were significant increases in the measurements of U1 to SN and the IMPA by 0.4° ± 0.6° (*P* = .050) and 0.8° ± 0.8° (*P* = .002), respectively. The interincisal angle also decreased by 1.0° ± 1.4° (*P* = .018). When comparing the two groups, the WCR group showed statistically significant greater changes in the interincisal angle (*P* = .014) and IMPA (*P* = .002). Minor changes were noted in the linear measurements from U6 and U1 to the Palatal Plane (PP), and L1 and L6 to the Mandibular Plane (MP), without any significant differences between the groups. Similarly, no significant differences were observed in the angular measurement of U1 to SN and between the occlusal planes. The absolute mean measurement errors for the cephalometric measurements for U6 to PP, U1 to PP, L1 to MP, L6 to MP, Occ. Plane, U1 to SN, Interincisal, and IMPA were 0.41, 0.34, 0.42, 0.33 mm, 0.30, 0.25, 0.40, 0.31 degrees, respectively.

Table 3. Changes in cephalometric parameter during 1 year of retention between two retainer groups.

Outcome Variable	WCR		CCR		Intergroup difference *P* value [b]
	Mean difference ± SD (T0-T2)	Intragroup difference *P* value [a]	Mean difference ± SD (T0-T2)	Intragroup difference *P* value [a]	
U6 to PP, mm	-0.1 ± 0.4	.463	-0.1 ± 0.3	.501	.779
U1 to PP, mm	0.0 ± 0.3	.637	0.0 ± 0.4	.855	.667
L1 to MP, mm	-0.2 ± 0.3	.064	-0.1 ± 0.3	.294	.527
L6 to MP, mm	0.2 ± 0.5	.284	0.1 ± 0.2	.116	.705
Occ.Plane angle, °	-0.1 ± 0.8	.719	0.2 ± 0.5	.139	.258
U1 to SN, °	0.4 ± 0.6	.050*	0.0 ± 0.5	.976	.096
Interincisal angle, °	-1.0 ± 1.4	.018*	0.1 ± 1.0	.703	.014*
IMPA, °	0.8 ± 0.8	.002*	-0.2 ± 0.8	.439	.002*

[a] paired T-test; [b] independent T-test. WCR, wrap-around circumferential retainer; CCR, customized clear retainer

3.4. Changes in patient perspective and attitude

Records from 32 subjects (14 in WCR group, 18 in CCR group) who completed both surveys at 1-month and 1-year follow-up were included for patient perspective analysis. A total of nine questions were answered by each participant about the wearing time, discomfort, and satisfaction associated with their retainers. The responses are summarized in Tables 4 and 5.

Questions regarding retainer wearing time per day were included in the cooperation section. Although participants were prescribed to wear their retainers all day for the first month, only 21.4% in CCR and 33.3% WCR wore them for more than 12 hours. There was no significant difference in wearing time between the groups at either T1 (P = 0.549) or T2 (P =0.403).

The discomfort section comprised three questions about irritation, vomiting, and discomfort while talking, rated on a 5-point Likert scale (from strongly agree to strongly disagree). At T1, a higher percentage of respondents in WCR group reported irritation compared to CCR group (P = .037). By T2, more patients in WCR group reported discomfort while speaking while using the retainers compared to CCR group (P = .038). Nearly all patients in both groups reported no vomiting incidents, with no significant difference between the groups.

Five questions addressed satisfaction, covering aspects like retainer breakage, time spent wearing the retainer, embarrassment caused by the retainer, cleaning of the retainer, and relapse. No significant differences were found between the two groups in these aspects. While no significant

differences emerged between the two groups in these areas, a notable proportion of participants in the CCR group reported that retainers were easier to clean and did not cause any psychological embarrassment, highlighting a difference in user experience related to these specific aspects.

Table 4. Questionnaire for patient cooperation, discomfort, and satisfaction at T1 (1 month after debond).

Section	Question	Response	WCR Frequency n (%)	CCR Frequency n (%)	*P* value
Cooperation	How much time do you wear your retainers per day?	>12 hrs	3 (21.4)	6 (33.3)	0.549
		10~12 hrs	3 (21.4)	5 (27.8)	
		8~10 hrs	1 (7.1)	3 (16.7)	
		6~8 hrs	6 (42.9)	4 (22.2)	
		<6 hrs	1 (7.1)	0 (0)	
Discomfort	Irritation caused by retainer?	Strongly agree	0 (0)	0 (0)	0.037*
		Agree	3 (21.4)	1 (5.6)	
		Neutral	8 (57.1)	5 (27.8)	
		Disagree	1 (7.1)	9 (50)	
		Strongly disagree	2 (14.3)	3 (16.7)	
	Vomiting caused by retainer?	Strongly agree	0 (0)	0 (0)	1
		Agree	0 (0)	0 (0)	
		Neutral	0 (0)	0 (0)	
		Disagree	3 (21.4)	4 (22.2)	
		Strongly disagree	11 (78.6)	14 (77.8)	
	Discomfort when talking with retainer?	Strongly agree	2 (14.3)	0 (0)	0.053
		Agree	8 (57.1)	6 (33.3)	
		Neutral	4 (28.6)	5 (27.8)	
		Disagree	0 (0)	5 (27.8)	
		Strongly disagree	0 (0)	2 (11.1)	
Satisfaction	How often does the retainer break?	0	14 (100)	18 (100)	1
		1	0 (0)	0 (0)	
		>2	0 (0)	0 (0)	
	When do you usually wear retainer?	Daytime	0 (0)	0 (0)	0.235
		Night	12 (85.7)	11 (61.1)	
		Always	2 (14.3)	7 (38.9)	
	Are you embarrassed when wearing retainer?	Strongly agree	2 (14.3)	0 (0)	0.108
		Agree	4 (28.6)	1 (5.6)	
		Neutral	1 (7.1)	0 (0)	
		Disagree	2 (14.3)	5 (27.8)	
		Strongly disagree	3 (21.4)	9 (50)	
		Bothering but able to wear	2 (14.3)	3 (16.7)	
		Too embarrassing to wear	0 (0)	0 (0)	
	Was it easy to clean your retainer?	Strongly agree	2 (14.3)	5 (27.8)	0.519
		Agree	7 (50)	9 (50)	
		Neutral	5 (35.7)	4 (22.2)	
		Disagree	0 (0)	0 (0)	
		Strongly disagree	0 (0)	0 (0)	
	Do you think your teeth relapsed?	No	13 (92.9)	18 (100)	0.437
		Slightly	1 (7.1)	0 (0)	
		A lot	0 (0)	0 (0)	

WCR, wrap-around circumferential retainer; CCR, customized clear retainer.
* Statistically significant difference

Table 5. Questionnaire for patient cooperation, discomfort, and satisfaction at T2 (1 year after debond).

Section	Question	Response	WCR Frequency n (%)	CCR Frequency n (%)	*P* value
Cooperation	How much time do you wear your retainers per day?	>12 hrs	0 (0)	0 (0)	0.403
		10~12 hrs	1 (7.1)	0 (0)	
		8~10 hrs	3 (21.4)	6 (33.3)	
		6~8 hrs	4 (28.6)	8 (44.4)	
		<6 hrs	6 (42.9)	4 (22.2)	
Discomfort	Irritation caused by retainer?	Strongly agree	0 (0)	0 (0)	0.439
		Agree	1 (7.1)	0 (0)	
		Neutral	7 (50)	7 (38.9)	
		Disagree	5 (35.7)	7 (38.9)	
		Strongly disagree	1 (7.1)	4 (22.2)	
	Vomiting caused by retainer?	Strongly agree	0 (0)	0 (0)	0.609
		Agree	0 (0)	0 (0)	
		Neutral	1 (7.1)	0 (0)	
		Disagree	2 (14.3)	2 (11.1)	
		Strongly disagree	11 (78.6)	16 (88.9)	
	Discomfort when talking with retainer?	Strongly agree	1 (7.1)	0 (0)	0.038*
		Agree	5 (35.7)	5 (27.8)	
		Neutral	7 (50)	3 (16.7)	
		Disagree	1 (7.1)	6 (33.3)	
		Strongly disagree	0 (0)	4 (22.2)	
Satisfaction	How often does the retainer break?	0	13 (92.9)	18 (100)	0.437
		1	1 (7.1)	0 (0)	
		>2	0 (0)	0 (0)	
	When do you usually wear retainer?	Daytime	0 (0)	1 (5.6)	1
		Night	14 (100)	17 (94.4)	
		Always	0 (0)	0 (0)	
	Are you embarrassed when wearing retainer?	Strongly agree	2 (14.3)	0 (0)	0.239
		Agree	4 (28.6)	7 (38.9)	
		Neutral	2 (14.3)	1 (5.6)	
		Disagree	1 (7.1)	2 (11.1)	
		Strongly disagree	2 (14.3)	0 (0)	
		Bothering but able to wear	3 (21.4)	8 (44.4)	
		Too embarrassing to wear	0 (0)	0 (0)	
	Was it easy to clean your retainer?	Strongly agree	2 (14.3)	6 (33.3)	0.288
		Agree	8 (57.1)	8 (44.4)	
		Neutral	4 (28.6)	2 (11.1)	
		Disagree	0 (0)	0 (0)	
		Strongly disagree	0 (0)	2 (11.1)	
	Do you think your teeth relapsed?	No	14 (100)	17 (94.4)	1
		Slightly	0 (0)	1 (5.6)	
		A lot	0 (0)	0 (0)	

WCR, wrap-around circumferential retainer; CCR, customized clear retainer.
* Statistically significant difference

4. Discussion

The success of the retention phase after orthodontic treatment depends as much on the chosen appliance as on patient compliance. The present study aimed to investigate the effectiveness of two types of retainers, WCR and CCR, by comparing clinical outcomes and patient preferences.

The present study involved cohorts where widely adapted combination of a fixed (cuspid-to-cuspid bonded lingual) and removable retainers was prescribed following active orthodontic treatment (Barlin et al. 2011; Rowland et al. 2007). When comparing clinical outcomes between groups, there were no significant differences in overjet, overbite, and both maxillary and mandibular intercanine and molar widths, based on model analyses. However, a notable difference in maxillary intermolar width was found between the groups during the first year of retention. The observed variation in WCR (ranging from -0.6 to 0.4 mm) suggested a mild tendency toward a reduction in arch width compared to CCR (ranging from -0.3 to 0.9 mm). Considering the absolute mean measurement error for maxillary intermolar width was 0.2 mm, the small differences in mean values indicate that these changes may not be clinically significant. There have been concerns about the ability of the less rigid thermoplastic material of CCR retainers to maintain the transverse dimension. Despite this, several studies have shown that CCR retainers are just as effective as WCR retainers in maintaining both intercanine and intermolar widths (Ashari et al. 2022a; Ashari et al. 2022b).

The cephalometric analysis showed significant changes in the WCR group after 12 months of retention, specifically in the inclination of upper and lower incisors and the resulting interincisal angle. The differences observed in the WCR group were both substantial and statistically significant when compared to the CCR group. In this study, the WCR group exhibited a tendency for both maxillary and mandibular incisors to incline labially, with a more pronounced effect in the mandible, showing an average increase of 0.8°. This tendency may be linked to the design of CCR retainers, which cover the entire tooth crown, in contrast to WCR retainers that contact the tooth at specific points. Despite the similar occlusal force distribution with CCRs, the decrease in occlusal contacts due to the full coverage might have altered the anterior force component, thereby reducing its impact on the inclination of the lower incisors (Acar, Alcan, and Erverdi 2002; Alkan and Kaya 2020; Singh et al. 2023). While numerous studies have assessed the long-term retention efficacy of these retainers, cephalometric analysis has been infrequently included in such studies (Al-Moghrabi, Littlewood, and Fleming 2021; Krämer et al. 2023; Naraghi et al. 2023). Hardly any studies have reported on changes in incisor inclination during retention using cephalometric analysis, making the present findings unique.

Considering clinical effectiveness, this inference suggests that full-coverage retainers, such as CCRs, might be the preferred option for cases with a higher risk of relapse in the mandibular incisors. This is particularly relevant in the presence of persistent tongue thrusting habits or in cases involving total distalization of mandibular teeth without extraction.

As mentioned in the introduction, evaluating posterior occlusion changes before and after the retention period could help clarify the impact of CCRs on occlusal settling and interdigitation. Future studies incorporating tools such as T-scan occlusal analysis or 3D superimposition of intraoral scans may offer deeper insight into occlusal changes during the retention phase, providing a stronger rationale for individualized retainer selection.

Recognizing the importance of patients' experiences, this study was specifically designed to explore three aspects of the retainer experience: cooperation, discomfort, and satisfaction. In addition to conducting a survey at the trial's conclusion (T2), the study also examined the early impact on participants' attitudes with a short-term 1-month follow-up (T1). Wearing duration has a direct impact on the overall stability of orthodontic retention. More than 60% of participants in the CCR group adhered to wearing their retainers for over 10 hours a day at T1. However, by T2, the duration of retainer wear decreased to less than 6 hours for 42.9% of respondents in the WCR group, in contrast to 22.2% in the CCR group. These observations suggest that early experiences with retainers influence long-term compliance, consistent with previous studies reporting better early compliance with CCRs (Pratt, Kluemper, and Lindstrom 2011).

The comfort assessment with two retainer groups showed that a greater number of WCR participants observed irritation during the first month of retention. However, at T2 there was no significant difference in terms of irritation between the two groups, indicating that patients adapted to their retainers over time, reducing irritation. These observations align with the previously reported superior comfort of CCRs, attributed to the appliance's design being restricted to the tooth surface (Saleh, Hajeer, and Muessig 2017). Furthermore, a larger portion of WCR patients reported discomfort while speaking both at T1 and T2, with a significant difference noted at T2. Compared to 55.5% of CCR group participants only 7.1% of WCR did not report any discomfort while speaking, suggesting that speech-related discomfort, particularly with WCR, remains a challenge to adapt to even after one year. These findings support the consensus-based evidence that CCRs cause less discomfort than WCRs, likely because CCR retainers do not extend to soft tissues such as the palate or gingiva but only cover the crowns, reducing inconvenience or pain (Al-Moghrabi, Littlewood, and Fleming 2021; Ashari et al. 2022b; Padmos, Fudalej, and Renkema 2018; Singh et al. 2023).

It should be noted that the greater maintainence in incisor inclination observed in the CCR group may not be solely attributable to the structural characteristics of the retainer itself. Since the retention capacity largely depends on patient cooperation, the difference in compliance between groups may have also played an important role in the observed outcomes.

Retainer satisfaction was evaluated through five questions covering breakage, wearing time, embarrassment, cleaning, and feeling of relapse. At T1 and T2, a significantly larger percentage of CCR (77.8% and 44.4%, respectively) disagreed with feeling embarrassed while wearing their retainers, compared to WCR (35.7% at both times), aligning with the common view that CCRs are more aesthetically pleasing than WCRs (Al-Moghrabi et al. 2019; Al-Moghrabi, Littlewood, and Fleming 2021; Kaklamanos et al. 2017; Saleh, Hajeer, and Muessig 2017). This suggests that CCRs

may be more advantageous in the initial months when patients are required to wear them throughout the day. However, no significant differences were found between the groups across these categories.

The absence of extended observation periods beyond a one-year follow-up constrains the ability to report outcomes over the entire retention period. he study also did not explore the potential influence of the Hawthorne effect on compliance, in which participants may alter their behavior simply due to the awareness of being observed. This may have led to temporarily increased cooperation or altered responses in questionnaires (Abdulraheem and Bondemark 2018). A further limitation of the study is the lack of detailed analysis on baseline characteristics, including initial patient conditions such as skeletal pattern and initial proclination of anterior teeth, as well as treatment modalities such as the use of a rapid palatal expander (RPE) or implementation of total arch distalization. This additional stratification might have provided more meaningful insights when interpreting the results. Furthermore, the inclusion criteria focused mainly on dental characteristics, and pre-screening for skeletal patterns could have increased the consistency of the study population. Additionally, a high drop-out rate during the one-year follow-up was observed (44% in the WCR group, 33.3% in the CCR group). While this reduction in sample size impacts the study's statistical power, it should be considered when interpreting the clinical significance of the findings. However, the dropouts were perceived to have occurred at random thus a significant attrition bias was unlikely. Although retainer control appointments were scheduled, participant engagement in the follow-up stages of the study was insufficient. Future study designs should aim for larger sample sizes and more frequent follow-up reminders, along with incentives to encourage continued participation, for effective patient-centered outcomes (Timm et al. 2022; Zhang et al. 2022).

5. Conclusions

One year after debonding, the scan model analysis showed that both groups successfully maintained transverse arch width and arch length with minimal changes.

Cephalometric analysis revealed that there was a significant difference between two groups in maintaining incisor angulation. CCRs were especially effective in maintaining incisor inclination, making them a preferable option in retention cases with a higher risk of relapse in incisor inclination.

In terms of patient experience with retainers, no notable differences were observed in overall satisfaction or average wearing time; however, the CCRs showed higher acceptability, with less reported irritation after the fist month and reduced speech discomfort at the one-year follow-up.

Therefore, the null hypothesis can be rejected. CCRs are more effective in maintaining mandibular incisor inclination and are associated with less discomfort during the first year of retention.

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Abstract in Korean

두 가지 탈착식 유지장치를 이용한 교정치료 후 안정성 및 환자 만족도 평가: 무작위 대조 연구

교정 치료 후 탈착식 유지장치의 종류를 선택하는 문제는, 각 장치의 효과와 환자 협조도에 관한 연구가 충분치 않아 오랫동안 논쟁의 대상이 되어왔다. 따라서 본 연구의 목적은 두 가지 유형의 탈착식 유지장치, 즉 랩어라운드 유지장치(WCR)와 맞춤형 투명 유지장치(CCR)의 유지 효과 및 환자의 주관적 평가를 비교·분석하는 것이다.

이 코호트 추적 연구는 고정식 교정장치를 이용하여 악교정 수술을 동반하지 않는, 비발치 교정치료를 완료한 18 세에서 62 세 사이의 환자 52 명을 대상으로 진행하였다. 연구 참여에 동의한 후, 피험자들은 WCR 군과 CCR 군으로 랜덤하게 배정되었다. 모든 참가자는 추적 관찰 시작 전에 상·하악 전치부에 고정식 설측 유지장치를 부착하였고, 교정장치 제거 2 주 이내에 해당 탈착식 유지장치의 착용을 시작하였다. 교정장치 제거 직후(T0)와 12 개월 후(T2)에 구강 스캔 및 측모두부방사선사진 촬영을 진행하여, 시간에 따른 골격 및 치성 계측치의 변화를 분석하였다. 또한, 유지장치 장착 1 개월(T1) 및 12 개월(T2) 시점에 각 유지장치에 대한 참가자의 협조도와 만족도를 평가하기 위해 설문조사를 실시하였다. 결과 분석 시, 평가자 눈가림(blinding)이 시행되었으며, 주요 골격 및 치성 계측치 분석 시 군 내에서는 대응표본 t 검정, 군 간에서는 독립표본 t 검정을 사용하였다. 설문조사 결과는 피어슨 카이제곱 검정을 사용하여 분석하였다.

최종 평가에는 총 32 명의 참가자가 포함되었다. 모델 분석 결과, 상악 대구치 간 폭경(P = 0.033)을 제외한 대부분의 측정값에서 두 군 간 유의한 차이는 없었다. WCR 군에서는 측모두부방사선사진 분석 시 하악 전치-하악평면각(IMPA)의 유의한 증가(P = 0.002)와 절치간각(interincisal angle)의 유의한 감소(P = 0.014)가 나타났으며, CCR 군에서는 통계적으로 유의한 변화가 관찰되지 않았다. 설문조사 결과, 유지장치 장착 시간 및 전반적 만족도 면에서 두 군 간 유사한 경향을 보였으나, WCR 군에서 장착 1 개월 시점(T1)의 유지장치로 인한 자극(P = 0.037)과 12 개월 시점(T2)의 발음 시 불편감(P = 0.038)은 CCR 군에 비해 유의하게 더 큰 값을 보였다.

결론적으로, CCR 은 하악 전치부의 치축 경사도 유지 측면에서 WCR 보다 우수한 유지력을 보였고, 장착 시 구강 내 자극과 발음 시 불편감은 상대적으로 적었다.

핵심이 되는 말: 투명 유지장치, 랩어라운드 유지장치, 탈착식 유지장치, 유지안정성, 환자 만족도, 무작위 임상시험