The effect of lingual orthodontic appliances in the dimensional reduction of labial gingival recession and root prominence caused by wire syndrome in the anterior mandible: a multicenter study

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Objective: Wire syndrome or X-effect/twist-effect describes undesired long-term tooth movements following fixed retainer placement. Since it includes root torque changes that might cause gingival recession, those situations often require periodontal, orthodontic, and conservative treatment. The aim of this study was to assess the effectiveness of fixed orthodontic treatment with completely customized lingual appliances (CCLAs) and continuous archwires for a clinically significant reduction in the dimensions of labial gingival recessions in the anterior mandible, caused by wire syndrome, in a group of consecutive patients treated with the same approach. Moreover, the reduction in root prominence of the affected teeth relative to the two neighboring teeth was evaluated. **Method and materials:** This retrospective cohort study from three centers included 20 consecutively recruited patients with labial gingival recession at mandibular incisors and canines due to wire syndrome. A total of 25 teeth were assessed. CCLA treatment with a standardized archwire sequence (0.012″/0.014″ NiTi, 0.016″ × 0.022″ NiTi, 0.018″ × 0.018″ beta-titanium with optional extra-torque) was identical in all three centers. Primary endpoints of recession depth, recession width, and recession surface were assessed on digital models at debonding (T1) and compared to baseline (T0) both as absolute differences (T0 − T1), and as ratios ([T0 − T1]/T0) by one-sample *t* tests with $P < .05$. As a secondary endpoint, the reduction of root prominence relative to the gingival surface of the alveolar yoke of the two neighboring teeth was measured in millimeters. **Results:** Treatment resulted in a significant reduction in all dimensions of gingival recession. The mean reduction in recession depth was 1.86 mm (44.9%) and in recession width 0.70 mm (35.6%). The mean recession surface was reduced from 10.77 mm^2 to 3.93 mm^2, indicating a mean recession surface reduction of 61.4%. All changes were statistically significant ($P < .001$). The range of recession surface reduction was from 25.4% to 100%, and 18 out of the 25 recessions showed a reduction of more than 50%. The maximum reduction in root prominence amounted to more than 3 mm. **Conclusion:** The use of CCLAs to torque roots of the anterior mandibular teeth, exposed by wire syndrome, towards the middle of the alveolar process reduces the area of subsequent labial gingival recession and reduces the root prominence of the affected teeth substantially. This is considered a critical step in optimizing the predictability of surgical recession coverage. *(Quintessence Int 2025;56:306–317; doi: 10.3290/j.qi.b5984435)*

Keywords: alveolar yoke, completely customized lingual appliances, gingival recessions, recession depth, recession width, retainer twist-effect, retainer X-effect, root coverage, root prominence, torque, wire syndrome

Fixed retainers are commonly used to maintain the alignment of anterior teeth, particularly in the mandibular arch.[1-3] They secure the teeth in their corrected positions without relying on patient compliance. However, their effectiveness can be compromised due to failures, like breakage or loss of the retainer, or detachment of the wire from the teeth.[4] Beyond the risk of retainer failures, there is also the risk of unwanted movement of the retained teeth through the transfer of forces generated by the activation of a retainer, which remains clinically intact. These changes in the position of the teeth attached to the retainer cannot be characterized as relapse as they are not related to the initial malocclusion; they represent a new malocclusion induced by the active retainer. Katsaros et al[5] were the first to recognize and report these unwanted tooth movements caused

Fig 1a to d Examples for a wire syndrome, X-effect *(a and b)* and twist-effect *(c and d)*. In both cases, gingival recession is evident on the roots that are torqued labially out of the alveolar process.

by a retainer, usually a round spiral wire retainer, in a small fraction of patients. They described two different types of clinical situations: a torque difference between two adjacent teeth caused by the movement of the roots into opposite directions, later reported as X-effect[6] (Fig 1a and b), and an inclination change of a canine, the most distal tooth attached to the retainer. In later reports it was shown that this inclination change of the canine could be expressed with time as a progressive torque difference between adjacent teeth, with the canines finally being torqued in opposite directions, a so-called twist effect (Fig 1c and d).[6] These retainer-related unwanted effects were named later as “wire syndrome” (WS), a term that is now frequently used.[7]

A number of causes have been proposed for the development of WS, including the bonding of a wire that is not passive from the beginning, deformation of the wire during placement, wire distortion from biting on hard food or during professional dental cleaning, change in the mechanical properties of the wire, loss of bonding material with time, undetected wire detachment, and re-bonding of a detached wire in the active state, as well as the presence of parafunctions.[4,8]

Charavet et al[8] have identified 20 studies, mostly case reports or case series, presenting such clinical situations. These events have been reported to be progressive, ranging from minor displacements at the onset of WS to permanent damage such as bone dehiscence, gingival recession, or loss of vitality due to severe root displacements outside the bony envelope.[6-12]

Since WS can include both torque problems, and bone dehiscences/gingival recessions, those situations often require periodontal, orthodontic, and conservative dental care. This became increasingly evident in a subsequent number of reports in the field.[7,9,10,13-21] While removing the retainer and waiting for spontaneous correction of minor X-effects may be a sufficient strategy at the onset and in the early stages of WS, this may not be an adequate approach for periodontal tissue rehabilitation after root exposure and loss of attachment in severely torqued teeth. These more severe WS cases often require carefully planned orthodontic root movement to the center of the alveolar process prior to surgical root coverage.[22,23]

Since third order root movements are among the most difficult orthodontic movements to achieve, extremely precise appliances and treatment concepts are required. Laursen et al[23] demonstrated the suitability of a segmented arch approach to create forces and moments that redirect the incisor root towards the center of the alveolar process. As an alternative, completely customized lingual appliances (CCLAs) have been reported by a systematic review to be efficient in achieving individual, pre-set treatment goals.[24] Several authors have re-

Table 1 Subject and treatment characteristics

Characteristic		Result	
Total, n		20	
Sex, n (%)	Male	9 (45%)	
	Female	11 (55%)	
Age at T0, years	Mean ± SD	30.0 ± 7.0	
	Median	28.3	
	Min	20.3	
	Max	42.7	
Gingival recessions	Total, n	25	
	Canine, n (%)	1 (4%)	
	Lateral incisor, n (%)	6 (24%)	
	Central incisor, n (%)	18 (72%)	
		Holistic approach (n = 10)	**Partial approach (n = 10)**
Treatment time, years	Mean ± SD	2.0 ± 0.7	0.8 ± 0.2
	Median	2.1	0.8
	Min	1.2	0.4
	Max	3.4	1.1

SD, standard deviation.

ported high accuracies of CCLAs in transferring individual set-up treatment objectives into final tooth positions.[25-27] Jacobs et al[17] reported a series of three cases with WS in single teeth along with a gingival recession, that were successfully corrected with a CCLA, thereby underlining the capacity of CCLAs in root torque correction of severe WS cases.

The purpose of the present study was to assess the effectiveness of fixed orthodontic treatment with CCLAs and continuous archwires for a clinically significant reduction in the dimensions of labial gingival recessions and in root prominence (ROP), caused by WS at the anterior mandibular teeth, in a group of consecutive patients treated with the same approach.

Method and materials

Subjects

The approval for this retrospective cohort study was received from the ethical committee of the Hannover Medical School, Hannover, Germany (3151–2016). A recession was defined as a displacement of the soft tissue margin apical to the cemento-enamel junction (CEJ).[28] Subjects were consecutively included according to the following criteria.

Inclusion criteria were:

- labial gingival recessions in the anterior mandibular segment from canine to canine affected by WS (X-effect or twist-effect)
- lingual fixed appliance treatment with a CCLA (WIN, DW Lingual Systems)
- documentation by intraoral scans or plaster casts at baseline and at the end of active treatment.

Exclusion criteria were:

- treatment stopped ahead of schedule by patient or orthodontist.

Twenty consecutively treated patients from three different centers presenting with 25 labial gingival recessions in the anterior mandibular segment could be included in this multicenter study (CG, CK, LBH). No patients were excluded due to missing records or poor compliance. Detailed subject and treatment characteristics are shown in Table 1.

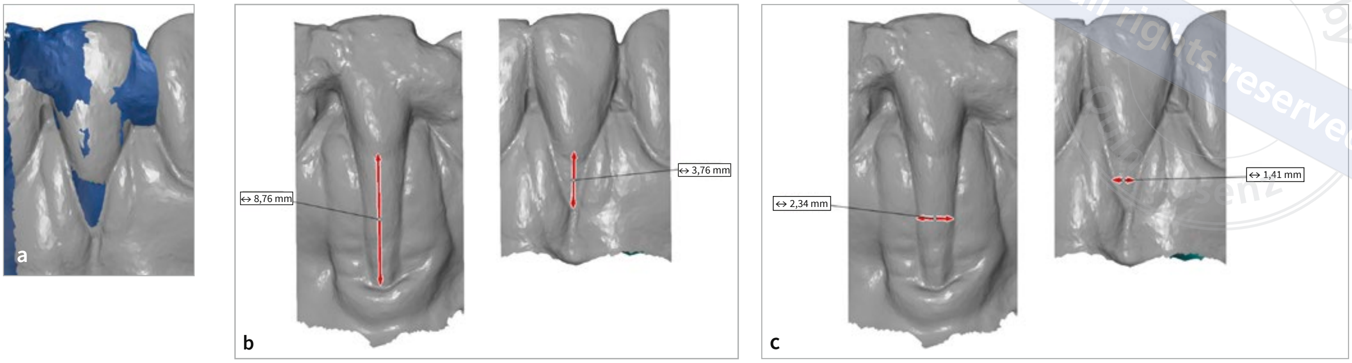
Intervention

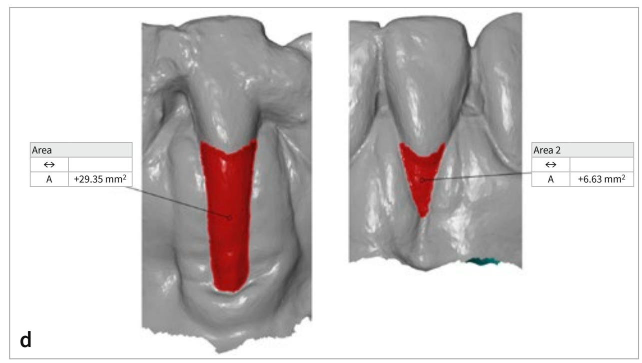
All patients received orthodontic CCLA treatment for the correction of the WS teeth as part of an individual treatment plan. This could be either a holistic approach, where WS was one of several reasons for the retreatment (n = 10 patients), or a partial approach, where WS was the single reason for the orthodontic retreatment (n = 10 patients). Treatment in the study subjects was carried out with an identical approach and a standardized archwire sequence in all three centers: 0.012″/0.014″ NiTi, 0.016″ × 0.022″ NiTi, 0.016″ x 0.024″ stainless steel (optional), and 0.018″ × 0.018″ beta-titanium as a finishing archwire. Subsequently, and based on a clinical assessment, additional selective lingual root torque of 13 degrees was applied on those teeth affected by root exposure, if necessary, using an additional 0.018″ x 0.018″ beta-titanium archwire.

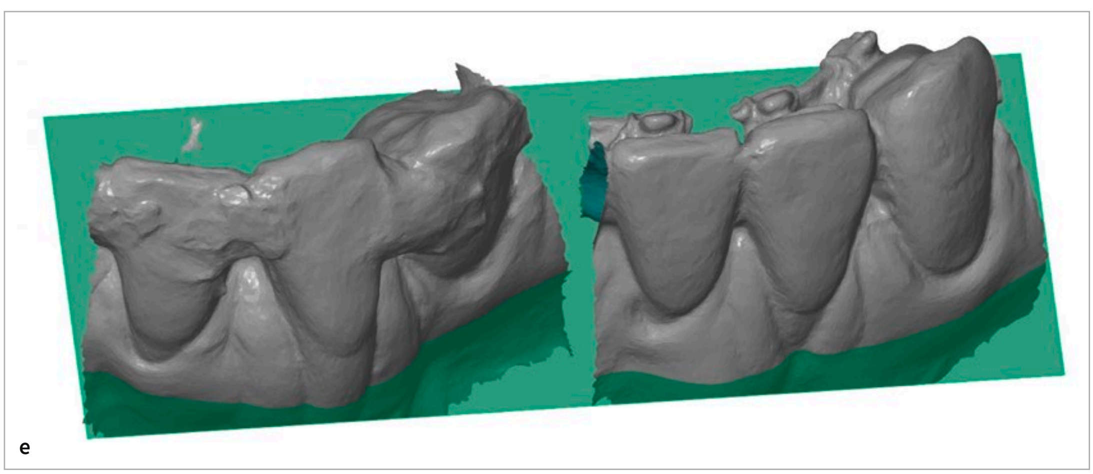
Measurements

In all 20 patients the fixed retainers were removed immediately after diagnosing WS. At least 4 weeks later digital models at T0 were derived directly from intraoral scans, or plaster casts were poured from two-phase silicone impressions and scanned. Final digital models at the end of treatment (T1) were either intraoral scans or scanned plaster casts from alginate impressions.

Recession depth (RD, mm), width (RW, mm), and surfaces (RS, mm^2) were measured at T0 and T1 by one trained exam-







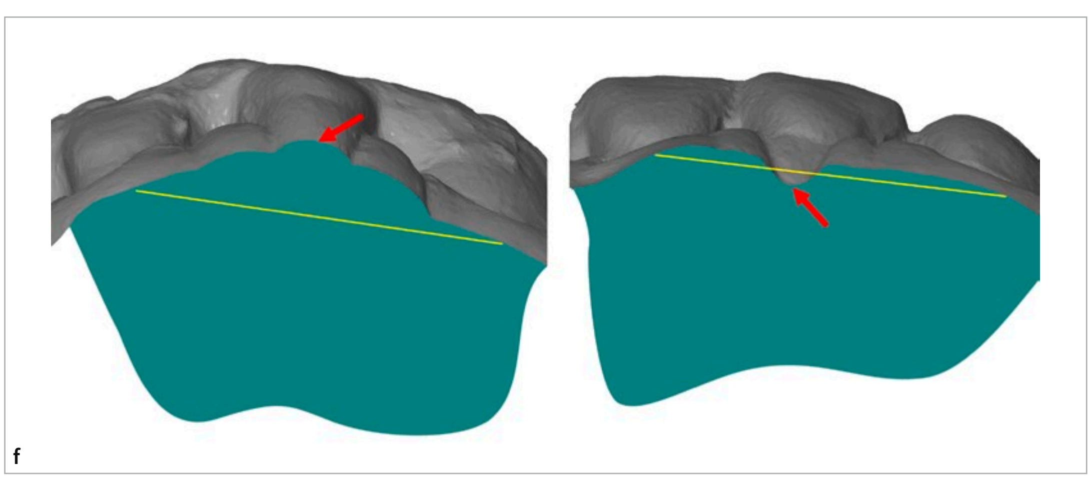


Fig 2a to f *(a)* The crown and part of the root of the tooth with the recession was superimposed digitally at T0 and T1 using a best fit algorithm (GOM software 2021) to ensure identical definition of the CEJ on both digital models in order to be used as a reference for all further 3D measurements. *(b)* Measurement of the recession depth (RD) from an identical point on the CEJ to the deepest point of the recession. *(c)* Measurement of the recession width (RW) midway between the CEJ and the deepest point of the recession. *(d)* Marking of the recession borders and calculation of the recession surface (RS). *(e, f)* Evaluation of the root prominence (ROP) relatively to the neighboring teeth. For this, the deepest point of the recession at T1 was defined and transferred to the model at T0. The scans were cut parallel to the dental arch at this level (green). When turning the model 90 degrees, a reference line could be drawn from the gingival surface of the alveolar yokes of the two neighboring teeth (yellow, *f*). The amount of the root prominence (red arrow) was measured as the distance from the tooth point to the reference line at T0 and T1. Note: The bulky connections between the affected tooth and the adjacent teeth, seen in the pretreatment model, is the splint used to stabilize the highly mobile tooth for the removal of the retainer and during the time until the lingual appliance was bonded.

Table 2 Description of the measurements and intrarater reliability

Measurement	Description	ICC
Recession depth (RD) in mm	Distance from the CEJ to the deepest point of the recession	0.998
Recession width (RW) in mm	Distance from the right to the left side of the recession in the middle of the recession	0.993
Recession surface (RS) in mm^2	Recession surface calculated in 3D after marking the recession borders	0.991
Root prominence (ROP) in mm	Root prominence relative to the gingival surface of the alveolar yoke of the two neighboring teeth	0.996

Intraclass correlation coefficient (ICC) < 0.5: poor reliability; 0.5 ≤ ICC < 0.75: moderate reliability; 0.75 ≤ ICC < 0.9: good reliability; ICC ≥ 0.9: excellent reliability.

Table 3 Descriptive analysis of recession depth (RD) in mm, recession width (RW) in mm, recession surface (RS) in mm^2, and root prominence (ROP) in mm at T0 and T1

Variable	N	Mean	SD	Median	Min	Max
RD T0	25	3.91	2.43	3.2	1.0	10.7
RD T1	25	2.04	1.54	1.5	0.0	5.3
RW T0	25	1.97	0.52	2.1	1.2	3.1
RW T1	25	1.27	0.59	1.3	0.0	2.6
RS T0	25	10.77	8.83	7.8	2.3	39.6
RS T1	25	3.93	3.68	2.9	0.0	16.1
ROP T0	25	1.12	0.74	0.8	0.2	2.8
ROP T1	25	−0.03	0.42	−0.1	−0.8	0.6

SD, standard deviation.

Table 4 Test of the differences (T0 – T1)

Difference (T0 – T1)	N	Mean	SD	95% CI	Min	Max	*P* value
RD in mm	25	1.86	1.96	(1.06, 2.67)	−0.5	8.3	.0001
RW in mm	25	0.70	0.50	(0.49, 0.91)	0.0	2.1	< .0001
RS in mm^2	25	6.84	7.28	(3.83, 9.84)	1.3	33.5	.0001
ROP in mm	25	1.15	0.73	(0.85, 1.46)	0.4	3.4	< .0001

CI, confidence interval; SD, standard deviation.

Table 5 Test of the reduction ratios ([T0 – T1] × 100 / T0)

Ratio ([T0 – T1] / T0)	N	Mean	SD	95% CI	Min	Max	*P* value
RD in %	25	44.89	27.75	(33.43, 56.34)	−15.63	100	< .0001
RW in %	25	35.57	22.44	(26.30, 44.83)	0.00	100	< .0001
RS in %	25	61.42	21.20	(52.67, 70.17)	25.37	100	< .0001

CI, confidence interval; SD, standard deviation.

iner (JQS), using the Atos Q 12M scanner (Carl Zeiss Meditec), with the software GOM 2021 (2021 Hotfix 8, Rev. 152091, GOM). Its sensors capture up to 2 × 12 million points per scan, at a point distance of 0.03 to 0.12 mm. A measuring protocol was established where the crown and part of the root of the tooth with the recession was digitally superimposed at T0 and T1 with a "best fit" algorithm. In this way the CEJ could be identically defined on both digital models (T0 and T1, Fig 2a). RD was measured from the CEJ to the deepest point of the recession (Fig 2b). RW was measured midway of the distance from the CEJ and the deepest point of the recession (Fig 2c).[23] RS representing the denuded root surface was three-dimensionally calculated with the GOM software after marking the borders of the recession mesially, distally, and apically, and the CEJ coronally (Fig 2d). To evaluate the reduction in ROP of the affected teeth relative to the gingival surface of the alveolar yoke of the neighboring teeth, the amount of ROP was measured in millimeters at the deepest point of the recession at T1 (Fig 2e and f).

Statistics

Subject characteristics (age, duration of treatment, and measurement data) of this trial at baseline (T0) and the end of treatment (T1) were descriptively analyzed using mean ± standard deviation (SD), median, and minimum and maximum values (min–max). Primary endpoints were the RD, RW, and RS measurements at T0 and T1, and both were analyzed as absolute differences (T0 − T1) and ratio ([T0 − T1] × 100 / T0) by one-sample *t* tests, with corresponding null hypotheses H0 = 0 for the difference, and H0 = 1 for the ratio. A *P* value of < .05 was considered statistically significant. Due to the exploratory nature of the trial, no alpha correction was performed. Intrarater reliability was evaluated using intraclass correlation coefficients (ICCs). The software SAS v9.4 (SAS Institute) was used for all statistical analyses.

Results

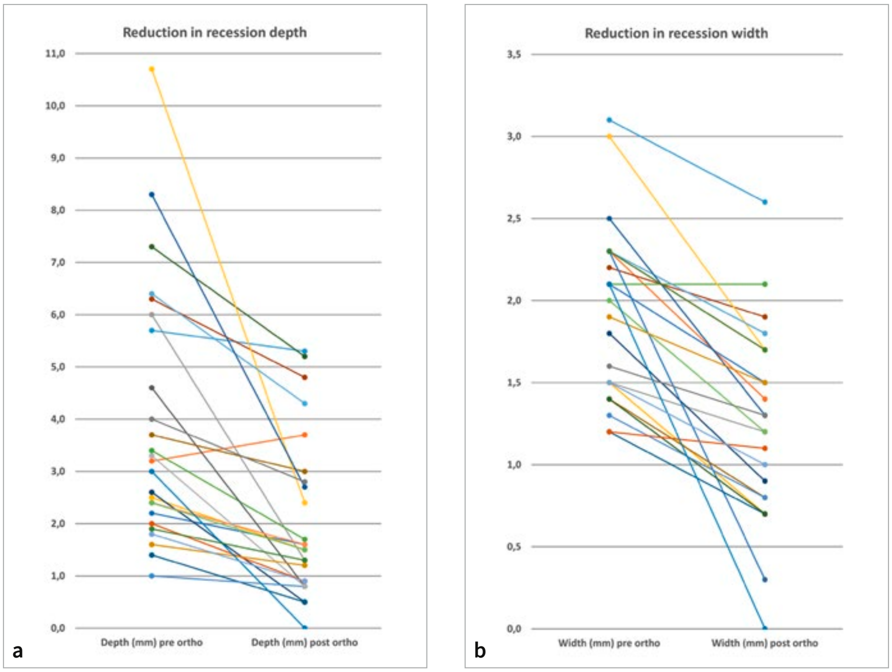
The baseline characteristics of the included subjects are shown in Table 1. Baseline and final digital models of 10%, equal to n = 3 arbitrarily chosen study subjects, were reassessed 1 month later by the same examiner (JQS) to assess the accuracy and reproducibility of the RD, RW, RS, and ROP measurements using ICC. The results showed a very high correlation of repeated measurements (Table 2).

The results of the measurements at T0 and T1 are shown in Tables 3, 4, and 5. Mean pretreatment RD was reduced from 3.91 mm to 2.04 mm (44.9% reduction) and the mean RW at T0 was reduced from 1.97 mm to 1.27 mm (35.6% reduction). There was an average reduction in RS of 61.4% (from 10.77 mm^2 to 3.93 mm^2). The mean reduction in ROP was 1.15 mm, ranging from 0.4 mm to 3.4 mm. The changes in all four components (RD, RW, RS, and ROP) were statistically significant (Tables 4 and 5). The lower limit of the 95% confidence interval (CI) indicates that a reduction of at least 1.00 mm for RD and at least 0.49 mm for RW can be expected with 95% certainty (Figs 4, 5, and 6). Furthermore, the limits of the 95% CI indicate that a mean reduction of RS between 53% and 70% can be expected with 95% certainty. In 18 of 25 teeth (72%) a reduction in RS of at least 50% was achieved, and in 23 of 25 teeth (92%) a reduction in RS of at least 30% was achieved. Figures 3a to e show the individual changes in RD, RW, RS, and ROP for all 25 recessions from T0 to T1.

Discussion

This is the first investigation with a relative high number of included patients that demonstrates the capacity of CCLAs in combination with continuous archwires to achieve a clinically significant reduction in the dimensions of gingival recessions and root prominence caused by WS. The results underline the efficiency of 3D torque control provided by CCLAs.[17,25-27,29-37] Presurgical orthodontic root movement led to a mean reduction in RD of 44.9%, RW of 35.6%, and RS of 61.4%. The range of RS reduction was 25.4% to 100%, and 18 out of the 25 recessions showed a reduction of more than 50%. To the present authors' knowledge, this is the first study to evaluate recession dimensional changes with orthodontic torque correction on 3D digital models. Laursen et al[23] reported an average reduction in RD of 23%, in RW of 38%, and in RS of 63% in a group of 12 patients treated with a segmented arch approach as measured on 2D clinical photographs. The results of the two studies are not directly comparable, due to the difference in methodology (2D vs 3D). The present study gives also for the first time important information on the significant reduction (up to 3.4 mm) of ROP of the affected teeth relative to the neighboring teeth, which can be achieved by the orthodontic root movement. The results of the present study are of high clinical relevance for interdisciplinary treatment planning and, in the absence of studies with a comparable sample size, these findings can be used to inform patients affected by WS about the changes that can be expected with orthodontic torque correction alone.

If WS is detected early, removing the retainer may be sufficient for the tooth position to self-correct or at least to prevent further worsening.[14] In these cases, care must be taken to avoid relapse of the non-affected teeth after retainer removal. If a complication remains undetected and gingival recession develops, an interdisciplinary consultation and treatment approach is necessary. Beitlitum et al[38] compared perio-surgical reconstruction of WS-affected teeth with and without removal of retainers prior to surgery and found 87.2% improvement of RD after prior removal of the fixed retainer, compared to 43.8% without. This difference has been attributed to spontaneous correction of the position of the affected teeth in the period between retainer removal and surgery. However, when the root of an affected tooth is prominent relative to the adjacent teeth, indicating a severe torque discrepancy, removal of the retainer alone and possible spontaneous correction is not sufficient to



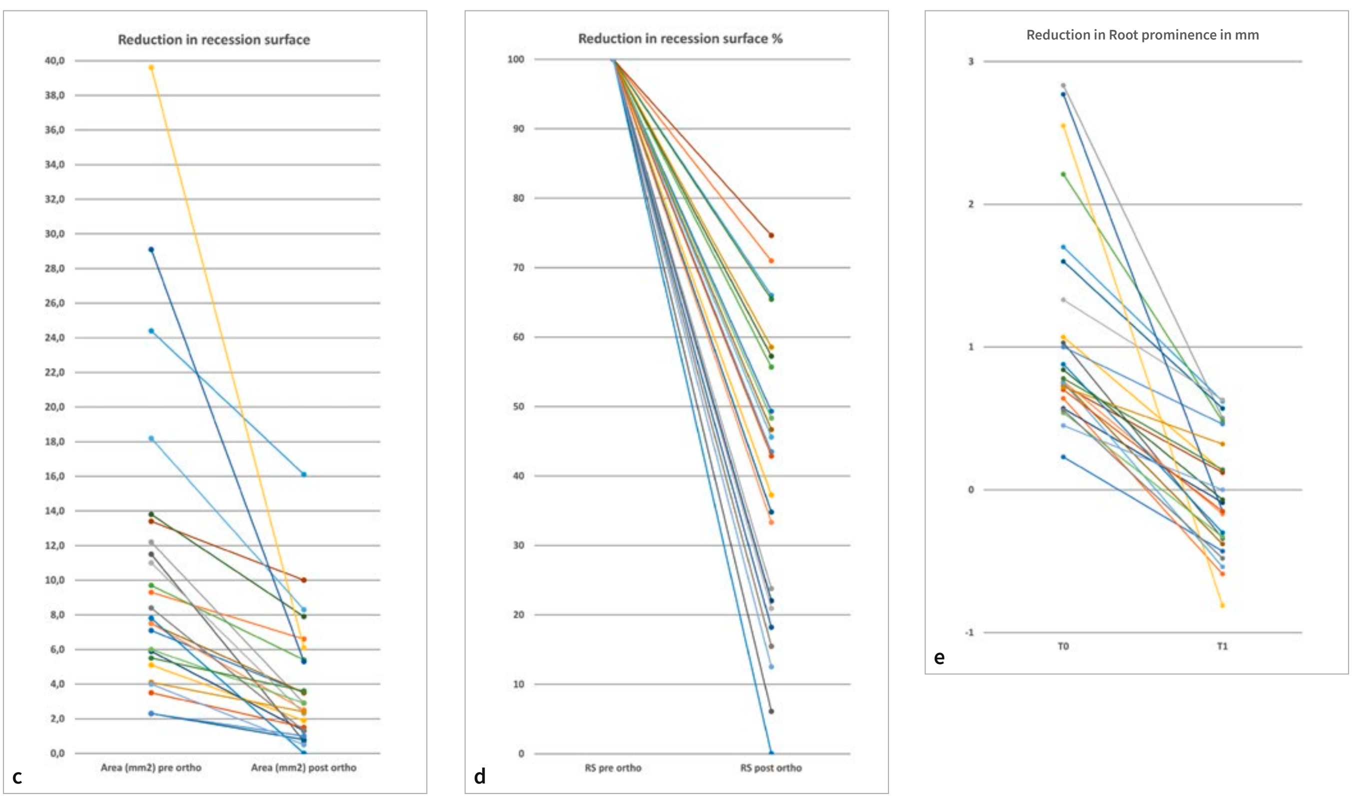


Fig 3a to e Reduction of recession depth in mm from T0 to T1 *(a)*; reduction of recession width in mm from T0 to T1 *(b)*; reduction of the recession surface from T0 to T1 *(c)*; reduction of the recession surface at T1 in relation to the surface size at T0 (100%) in percent *(d)*; reduction in root prominence (ROP) from T0 to T1 relative to the gingival surface of the alveolar yoke of the two neighboring teeth (0-mm level, *e*).

assist surgical coverage of the gingival recession. Correction of the torque discrepancy and root position prior to surgical recession coverage is a critical step in optimizing the predictability of the surgical procedure.[17,23] It contributes to a reduction in the recession surface and in the ROP relative to the gingival tissues of the adjacent teeth. Studies have shown that the success of various surgical root coverage procedures strongly depends on factors such as root position, position of the tooth (eg, in the maxilla or mandible, anterior or posterior areas), interproximal bone loss, recession depth and width, the depth

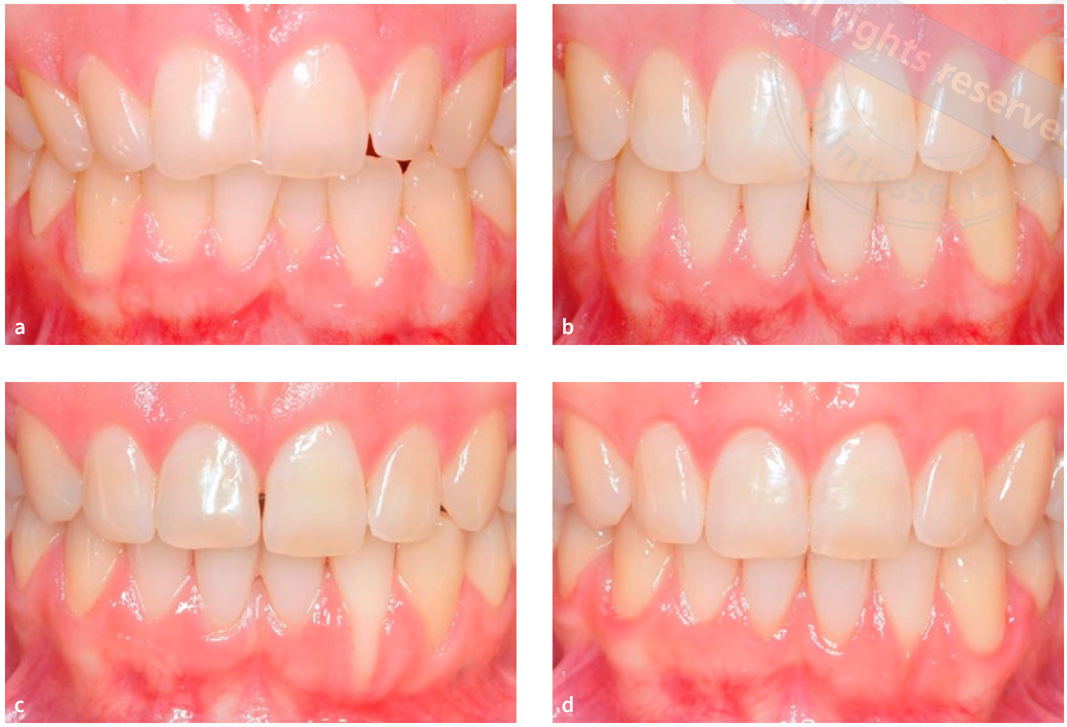


Fig 4a to d Young adult patient with anterior crowding *(a)*; situation after the orthodontic correction and placement of a fixed retainer in the mandible from the canine to canine *(b)*; X-effect with severe labial recession on the mandibular left lateral incisor (tooth 32) 5 years later *(c)*, after a 9-month treatment with a sectional CCLA (second premolar to second premolar) the ROP of tooth 32 could be reduced by 2.3 mm (lingual root torque) and the recession surface could be substantially reduced by 76% *(d)*.

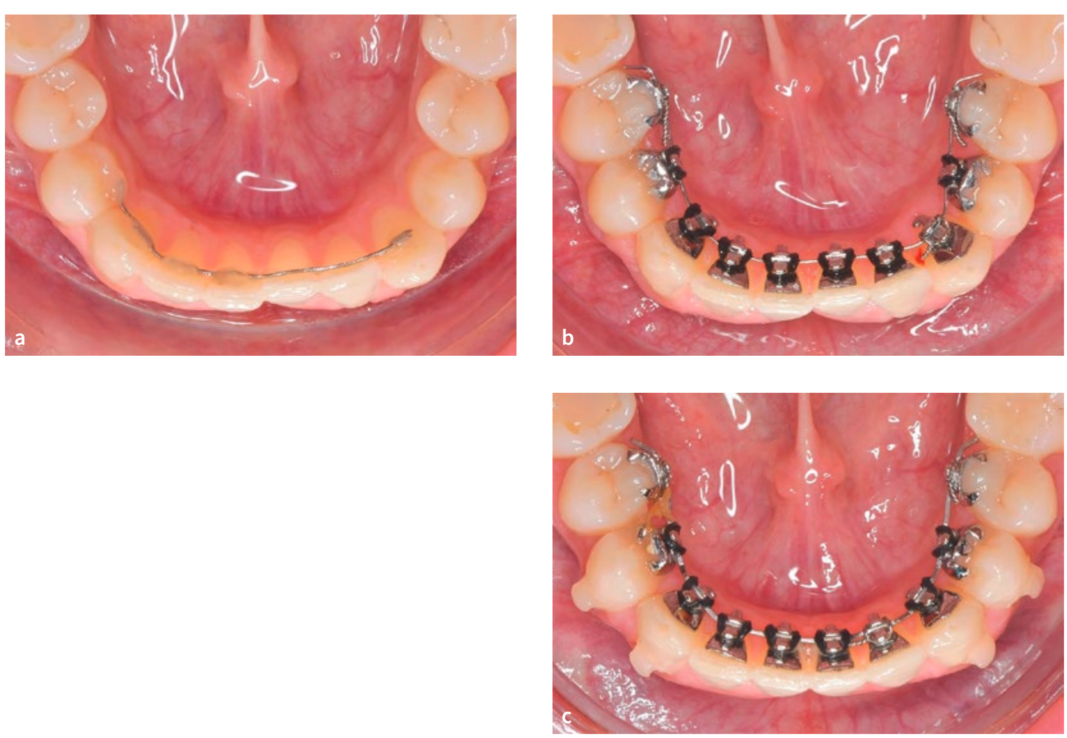


Fig 5a to c Same patient as in Fig 4: X-effect on spiral retainer wire 5 years after the active orthodontic treatment *(a)*; sectional CCLA after indirect bonding *(b)* and at the end of retreatment *(c)*.

Fig 6a to d Same patient as Fig 1a and b, with a severe gingival recession and root protrusion *(a, b)*. At T1, after fixed orthodontic therapy with a sectional CCLA, the recession surface is substantially reduced (85%) *(c)* and the reduction in ROP amounted to more than 3 mm *(d)*.

of the vestibule, the surgical technique used, and the operator's skill, as well as oral hygiene and smoking status.[39,40] The positive effects of orthodontic tooth movement in reducing recession dimensions and ROP are clearly demonstrated in the present study, highlighting the significant role of orthodontic treatment in improving recession defects and subsequently laying the foundation for enhancing the predictability of surgical recession coverage procedures. Based on a better understanding of the biologic processes involved in periodontal wound healing, as well as the systemic and anatomical factors that influence the clinical outcomes, surgical techniques have been developed to achieve predictable results, even in challenging clinical scenarios.[39,41,42]

The primary indications for treating gingival recessions are to reestablish an environment that facilitates effective self-performed oral hygiene, prevent gingivitis, root caries, and further attachment loss, as well as to improve esthetics. Additionally, evidence suggests that untreated gingival recessions carry a high risk of further progression. Findings from a systematic review revealed that after a 2-year follow-up period, 78.1% of recessions exhibited further progression (ie, an increase in recession depth), while the total number of defects increased by 79.3%.[43] Findings of another study conducted in dental students exhibiting high levels of oral hygiene, demonstrated the presence of buccal gingival recessions in 85% of the subjects. After 10 years, the number of sites and the depth of the recessions increased statistically significantly, suggesting that untreated gingival recessions are more likely to further deteriorate (ie, increase in depth).[44] These findings were corroborated by the results of a long-term follow up study over a period of 25 years, showing that treatment of gingival recessions by means of soft tissue augmentation (ie, free gingival graft) stopped further deterioration, as compared to untreated sites.[45] Moreover, untreated sites showed a statistically significant increase in the recession depth, while 83.5% of the treated recessions showed an improvement (ie, reduction in RD).

Postorthodontic recession defects frequently occur in the anterior mandibular region. To enhance the predictability of recession coverage in these challenging anatomical areas, techniques such as the modified coronally advanced tunnel (MCAT), the laterally closed tunnel (LCT), or a combination of MCAT and LCT, used in conjunction with subepithelial palatal connective tissue grafts (SCTG) or soft tissue replacement materials—with or without biologic factors—have been developed.[46-51] These techniques offer several advantages, including:

- they avoid vertical releasing incisions and incisions of the papillae, thereby improving vascularization and wound stability

- the coronal, lateral, or combined lateral and coronal displacement of the wound margins enables tension-free coverage of the root surfaces and soft tissue grafts with the tunneled flap, supporting graft survival and revascularization.

Increasing evidence indicates that these surgical techniques provide the best clinical outcomes in cases of single or multiple recessions at teeth that underwent orthodontic therapy.[46-51]

The use of a CCLA offers several advantages, including precise 3D-root control with self-limited tooth movement, as determined by the pre-set final tooth position. The appliance's self-limiting mechanics are particularly important in clinical situations involving a fragile periodontium.[39] In many cases, where only treatment in the anterior mandibular region is required, the lingual position of the segmented appliance avoids interference with the occlusion. At the same time the appliance remains invisible, offering an esthetic solution. Since many WS cases require complex tooth movements, comprehensive treatment planning based on thorough interdisciplinary diagnosis is essential.

The reported prevalence of WS in the anterior mandible differs considerably among studies. In the initial report by Katsaros et al[5] a prevalence of 5% was estimated. However, in a subsequent study of the same group, a prevalence of 2.7% was found 5 years posttreatment.[20] Later studies have reported a prevalence between 1.1% and 23%.[6,15,52-54] The sample size, observation time, retainer dimensions, and assessment methods differ between the studies and could partly explain the wide range. Although the prevalence of WS seems to be relatively low, the widespread use of round spiral wire retainers can result in a substantial number of patients at risk.[1,55]

Since general dental practitioners and dental hygienists are often the patients' primary point of contact, they might be the first professionals exposed to the WS. It is, therefore, very important that not only orthodontists, but also patients, general dentists or dental specialists, and dental hygienists are informed about potential WS complications and trained to detect them, ideally at an early stage.[5] Educating dental health providers on WS awareness is essential, as studies have shown that many general dental practitioners are very often unaware of this issue, and many orthodontists have limited experience with WS in their practices.[1,56]

After orthodontic correction of root position and surgical coverage of the defects in teeth affected by WS, it is very important to take measures to prevent recurrence of WS effects. Current evidence suggests that round spiral wires are not ideal for long-term retention. In contrast, robust rectangular braided wires appear not to produce adverse torque effects even 10 to 15 years posttreatment.[57] Similar results have been reported for thick stainless steel or beta-titanium wires bonded only to the mandibular canines, although a recent report has documented one WS case with this type of retainer.[58-60] Furthermore, with this type of wire there is a risk of increase in incisor irregularity during retention due to relapse of the incisors, which are not bonded to the retainer. An alternative retention wire – a 0.016″ × 0.022″ stainless steel retainer bonded ribbonwise on all anterior teeth – has been proposed and seems effective in maintaining incisor alignment with no WS events.[5,61] Since there is currently no perfect type of retainer, it is very important that patients with fixed retainers are checked annually by dental practitioners who have sufficient knowledge to recognize WS.

Limitations of the study

The retrospective nature of the study poses limitations in terms of selection bias and limited control over confounding factors. However, gingival recession due to WS is not a frequent finding. Therefore, the recruiting period in a similar study with a prospective design would be long and complicated to realize. This would be challenging, particularly in fields with rapid technological improvements. Although only 20 patients with 25 gingival recessions were included across three centers, this study has the largest sample size in the literature so far. It is also unique in that all patients were treated with the same lingual appliance and an identical archwire sequence. Patients were included consecutively, with no exclusions due to missing records or poor compliance. The present study focused only on post-orthodontic treatment outcomes; long-term stability of the results or potential relapse over time were not part of the investigation.

Conclusion

The use of a CCLA to torque roots of anterior mandibular teeth, exposed by WS, towards the middle of the alveolar process reduces the area of subsequent labial gingival recession and the ROP of the affected teeth substantially. This is considered as a critical step in optimizing the predictability of the surgical recession coverage.

Disclosure

The authors declare that they have no conflict of interest.

References

1. Lai CS, Grossen JM, Renkema AM, Bronkhorst E, Fudalej PS, Katsaros C. Orthodontic retention procedures in Switzerland. Swiss Dent J 2014;124:655–661.

2. Meade M, Dreyer C. A survey of retention and retainer practices of orthodontists in Australia. Aust Orthod J 2019;35:174–183.

3. Pratt MC, Kluemper GT, Hartsfield JK Jr, Fardo D, Nash DA. Evaluation of retention protocols among members of the American Association of Orthodontists in the United States. Am J Orthod Dentofacial Orthop 2011; 140:520–526.

4. Kouskoura T, Kloukos D, Pazera P, Katsaros C. Clinical effectiveness of bonded mandibular fixed retainers. In: Eliades T, Katsaros C (eds). Debonding and fixed retention in orthodontics: an evidence‐based clinical guide. Hoboken: Wiley-Blackwell, 2023:259–282.

5. Katsaros C, Livas C, Renkema AM. Unexpected complications of bonded mandibular lingual retainers. Am J Orthod Dentofacial Orthop 2007;132:838–841.

6. Kučera J, Marek I. Unexpected complications associated with mandibular fixed retainers: a retrospective study. Am J Orthod Dentofacial Orthop 2016;149:202–211.

7. Roussarie F, Douady G. A side-effect of bonded retention wires: the "wire syndrome": part 1. J Dentofacial Anom Orthod 2016;19:106.

8. Charavet C, Vives F, Aroca S, Dridi SM. "Wire syndrome" following bonded orthodontic retainers: a systematic review of the literature. Healthcare (Basel) 2022;10:379.

9. Shaughnessy TG, Proffit WR, Samara SA. Inadvertent tooth movement with fixed lingual retainers. Am J Orthod Dentofacial Orthop 2016;149:277–286.

10. Pazera P, Fudalej P, Katsaros C. Severe complication of a bonded mandibular lingual retainer. Am J Orthod Dentofacial Orthop 2012;142:406–409.

11. Farret MM, Farret MM, da Luz Vieira G, Assaf JH, de Lima EM. Orthodontic treatment of a mandibular incisor fenestration resulting from a broken retainer. Am J Orthod Dentofacial Orthop 2015;148:332–337.

12. Charavet C, Israël N, Vives F, Dridi SM. Importance of early detection of wire syndrome: a case series illustrating the main stages of the clinical gradient. Clin Pract 2023;13:1100–1110.

13. Singh P. Canine avulsion: an extreme complication of a fixed mandibular lingual retainer. Am J Orthod Dentofacial Orthop 2021;160:473–477.

14. Knaup I, Bartz JR, Schulze-Späte U, Craveiro RB, Kirschneck C, Wolf M. Side effects of twistflex retainers-3D evaluation of tooth movement after retainer debonding. J Orofac Orthop 2021;82:121–130.

15. Klaus K, Xirouchaki F, Ruf S. 3D-analysis of unwanted tooth movements despite bonded orthodontic retainers: a pilot study. BMC Oral Health 2020;20:308.

16. Kim T, Baek S. Lingual bonded retainers: A case series of complications and resolutions. APOS Trends Orthod 2020;10:3–11.

17. Jacobs C, Katzorke M, Wiechmann D, Wehrbein H, Schwestka-Polly R. Single tooth torque correction in the lower frontal area by a completely customized lingual appliance. Head Face Med 2017;13:18.

18. Egli F, Bovali E, Kiliaridis S, Cornelis MA. Indirect vs direct bonding of mandibular fixed retainers in orthodontic patients: Comparison of retainer failures and posttreatment stability. A 2-year follow-up of a single-center randomized controlled trial. Am J Orthod Dentofacial Orthop 2017;151:15–27.

19. Bonetti AG, Parenti SI; Zucchelli G. Onychophagia and postorthodontic isolated gingival recession: Diagnosis and treatment. Am J Orthod Dentofac Orthop 2012;142:872–878.

20. Renkema AM, Renkema A, Bronkhorst E, Katsaros C. Long-term effectiveness of canine-to-canine bonded flexible spiral wire lingual retainers. Am J Orthod Dentofacial Orthop 2011;139:614–621.

21. Abudiak H, Shelton A, Spencer R, Burns L, Littlewood S. A complication with orthodontic fixed retainers: a case report. Orthod Update 2011;4:112–117.

22. Cairo F, Nieri M, Pagliaro U. Efficacy of periodontal plastic surgery procedures in the treatment of localized facial gingival recessions. A systematic review. J Clin Periodontol 2014;41(Suppl 15):S44–S62.

23. Laursen MG, Rylev M, Melsen B. The role of orthodontics in the repair of gingival recessions. Am J Orthod Dentofacial Orthop 2020; 157:29–34.

24. Mistakidis I, Katib H, Vasilakos G, Kloukos D, Gkantidis N. Clinical outcomes of lingual orthodontic treatment: a systematic review. Eur J Orthod 2016;38:447–458.

25. Grauer D, Proffit WR. Accuracy in tooth positioning with a fully customized lingual orthodontic appliance. Am J Orthod Dentofacial Orthop 2011;140:433–443.

26. Pauls AH. Therapeutic accuracy of individualized brackets in lingual orthodontics. J Orofac Orthop 2010;71:348–361.

27. Pauls A, Nienkemper M, Schwestka-Polly R, Wiechmann D. Therapeutic accuracy of the completely customized lingual appliance WIN: A retrospective cohort study. J Orofac Orthop 2017;78:52–61.

28. Cortellini P, Bissada NF. Mucogingival conditions in the natural dentition: Narrative review, case definitions, and diagnostic considerations. J Periodontol 2018;89(Suppl 1): S204–S213.

29. Lossdörfer S, Schwestka-Polly R, Wiechmann D. Control of lower incisor inclination with a completely customized lingual appliance for dentoalveolar compensation of Class III malocclusion. J Orofac Orthop 2013;74:381–396.

30. Lossdörfer S, Bieber C, Schwestka-Polly R, Wiechmann D. Analysis of the torque capacity of a completely customized lingual appliance of the next generation. Head Face Med 2014;10:4.

31. Alouini O, Knösel M, Blanck-Lubarsch M, Helms HJ, Wiechmann D. Controlling incisor torque with completely customized lingual appliances. J Orofac Orthop 2020;81:328–339.

32. Beyling F, Klang E, Niehoff E, Schwestka-Polly R, Helms HJ, Wiechmann D. Class II correction by maxillary en masse distalization using a completely customized lingual appliance and a novel mini-screw anchorage concept – preliminary results. Head Face Med 2021;17:23.

33. Schmid JQ, Gerberding E, Hohoff A, Kleinheinz J, Stamm T, Middelberg C. Non-surgical transversal dentoalveolar compensation with completely customized lingual appliances versus surgically assisted rapid palatal expansion in adults-tipping or translation in posterior crossbite correction? J Pers Med 2023;13:807.

34. Janssens Y, Foley PF, Beyling F, Schwestka-Polly R, Schmid JQ. Quality of occlusal outcome in adult class II patients after maxillary total arch distalization with interradicular miniscrews. Head Face Med 2024;20:27.

35. Thiem LC, Rank P, Schmid JQ, Janssens Y, Bettenhäuser-Hartung L, Wiechmann D. Favourable dentoalveolar changes after lower premolar extractions for Class III camouflage with completely customized lingual appliances. Head Face Med 2024;20:57.

36. Schmid JQ, Gerberding E, Hohoff A, Kleinheinz J, Stamm T, Middelberg C. Non-surgical transversal dentoalveolar compensation with completely customized lingual appliances versus surgically assisted rapid palatal expansion in adults-the amount of posterior crossbite correction. J Pers Med 2022;12:1893.

37. Janssens Y, Foley PF, Beyling F, Stamm T, Schwestka-Polly R, Schmid JQ. Quality of occlusal outcome in adult Class II patients treated with completely customized lingual appliances and Class II elastics compared to adult Class I patients. Eur J Orthod 2024;46:cjae031.

38. Beitlitum I, Barzilay V, Rayyan F, Sebaoun A, Sarig R. Post-orthodontic lower incisors recessions: combined periodontic and orthodontic approach. Int J Environ Res Public Health 2020;17:8060.

39. Jepsen K, Sculean A, Jepsen S. Complications and treatment errors involving periodontal tissues related to orthodontic therapy. Periodontol 2000 2023;92:135–158.

40. Cairo F, Burkhardt R. Minimal invasiveness in gingival augmentation and root coverage procedures. Periodontol 2000 2023;91:45–64.

41. Chackartchi T, Gleis R, Sculean A, Nevins M. A novel surgical approach to modify the periodontal phenotype for the prevention of mucogingival complications related to orthodontic treatment. Int J Periodontics Restorative Dent 2021;41:811–817.

42. Kalimeri E, Roccuzzo A, Stähli A, et al. Adjunctive use of hyaluronic acid in the treatment of gingival recessions: a systematic review and meta-analysis. Clin Oral Investig 2024;28:329.

43. Chambrone L, Tatakis DN. Periodontal soft tissue root coverage procedures: a systematic review from the AAP Regeneration Workshop. J Periodontol 2015;86:S8–S51.

44. Matas F, Sentís J, Mendieta C. Ten-year longitudinal study of gingival recession in dentists. J Clin Periodontol 2011;38:1091–1098.

45. Agudio G, Chambrone L, Pini Prato G. Biologic remodeling of periodontal dimensions of areas treated with gingival augmentation procedure: a 25-year follow-up observation. J Periodontol 2017;88:634–642.

46. Sculean A, Cosgarea R, Stähli A, et al. The modified coronally advanced tunnel combined with an enamel matrix derivative and subepithelial connective tissue graft for the treatment of isolated mandibular Miller Class I and II gingival recessions: a report of 16 cases. Quintessence Int 2014;45:829–835.

47. Sculean A, Cosgarea R, Stähli A, et al. Treatment of multiple adjacent maxillary Miller Class I, II, and III gingival recessions with the modified coronally advanced tunnel, enamel matrix derivative, and subepithelial connective tissue graft: A report of 12 cases. Quintessence Int 2016;47:653–659.

48. Sculean A, Allen EP. The laterally closed tunnel for the treatment of deep isolated mandibular recessions: surgical technique and a report of 24 cases. Int J Periodontics Restorative Dent 2018;38:479–487.

49. Sculean A, Allen EP, Katsaros C, et al. The combined laterally closed, coronally advanced tunnel for the treatment of mandibular multiple adjacent gingival recessions: surgical technique and a report of 11 cases. Quintessence Int 2021;52:576–582.

50. Guldener K, Lanzrein C, Eliezer M, Katsaros C, Stähli A, Sculean A. Treatment of single mandibular recessions with the modified coronally advanced tunnel or laterally closed tunnel, hyaluronic acid, and subepithelial connective tissue graft: a report of 12 cases. Quintessence Int 2020;51:456–463.

51. Lanzrein C, Guldener K, Imber JC, Katsaros C, Stähli A, Sculean A. Treatment of multiple adjacent recessions with the modified coronally advanced tunnel or laterally closed tunnel in conjunction with cross-linked hyaluronic acid and subepithelial connective tissue graft: a report of 15 cases. Quintessence Int 2020;51:710–719.

52. Cornelis MA, Egli F, Bovali E, Kiliaridis S, Cattaneo PM. Indirect vs direct bonding of mandibular fixed retainers in orthodontic patients: Comparison of retainer failures and posttreatment stability. A 5-year follow-up of a single-center randomized controlled trial. Am J Orthod Dentofacial Orthop 2022;162:152–161.e151.

53. Gera A, Gera S, Cattaneo PM, Cornelis MA. Does quality of orthodontic treatment outcome influence post-treatment stability? A retrospective study investigating short-term stability 2 years after orthodontic treatment with fixed appliances and in the presence of fixed retainers. Orthod Craniofac Res 2022;25:368–376.

54. Charavet C, Israel N, Oueiss A, Masucci C, Fontas E, Dridi SM. What are the prevalence and risk factors associated with wire syndrome in dental students? A cross-sectional study. Int Orthod 2024;22:100899.

55. Renkema AM, Sips ET, Bronkhorst E, Kuijpers-Jagtman AM. A survey on orthodontic retention procedures in The Netherlands. Eur J Orthod 2009;31:432–437.

56. Habegger M, Renkema AM, Bronkhorst E, Fudalej PS, Katsaros C. A survey of general dentists regarding orthodontic retention procedures. Eur J Orthod 2017;39:69–75.

57. Kocher KE, Gebistorf MC, Pandis N, Fudalej PS, Katsaros C. Survival of maxillary and mandibular bonded retainers 10 to 15 years after orthodontic treatment: a retrospective observational study. Prog Orthod 2019;20:28.

58. Renkema AM, Al-Assad S, Bronkhorst E, Weindel S, Katsaros C, Lisson JA. Effectiveness of lingual retainers bonded to the canines in preventing mandibular incisor relapse. Am J Orthod Dentofacial Orthop 2008;134:179e171–178.

59. Kocher KE, Gebistorf MC, Pandis N, Fudalej PS, Katsaros C. Long-term effectiveness of maxillary and mandibular bonded orthodontic retainers. Oral Health Prev Dent 2020;18:633–641.

60. Abu Arqub S, Al-Moghrabi D, Tsichlaki A, Sanders D, Uribe F. The dark side of fixed retainers: Case series. Am J Orthod Dentofacial Orthop 2023;164:e72–e88.

61. Danz JC, Scherer-Zehnder I, Pandis N. A comparative assessment of three mandibular retention protocols: a prospective cohort study. Oral Health Prev Dent 2022;20:77–84.

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