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Case Report

Inadvertent Tooth Movement from a Bonded Mandibular Lingual Retainer—A Case Report with a Follow-Up 3D Analysis of Tooth Movement and a Microscopic Evaluation of the Wire

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Featured Application: This paper suggests that, in the case of a fixed retainer twist effect diagnosis, the retainer should be immediately removed, even if the patient is not keen on re-treatment in a short perspective.

Abstract: Background: One of the rarest complications of fixed orthodontic retention is inadvertent tooth movement of the teeth bonded to the retainer. A 25-year-old patient presented at the orthodontist as she was preoccupied about the position of the lower teeth. The aim of this case report was to present a follow-up of anterior teeth alignment after fixed retainer removal and to analyze the structure of the removed fixed orthodontic retainer in a patient suffering from a twist effect. **Materials and Methods:** The retainer that caused inadvertent movement has been removed, and subsequent teeth displacement was assessed with scan superimposition. The retainer structure and diameter were analyzed with a laser confocal microscope. **Results:** The superimposition showed significant improvements in the position of the teeth. The sole removal of the activated retainer resulted in a partial self-correction of the twist effect. Under microscopic observation, changes in the dimensions of the wire were found but were too small to cause significant changes in tooth position. **Conclusions:** A fixed retainer should always be removed when a twist effect is diagnosed. The wire sections covered with composite are less likely to untwist. In the presented case, the changes in the dimensions of the round retainer wire could not have led to changes in the teeth's positions.

Keywords: orthodontic retention; fixed retainer; twist effect; intraoral scan; 3D; fixed retention; scanning; microscope; case report

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1. Introduction

Orthodontic retention is the last phase of orthodontic treatment aiming to preserve the position of the teeth achieved during the active treatment phase. The maintenance of tooth position is achieved with both fixed and removable retainers according to the protocols applied by the clinicians, usually based on their own experience [1,2]. In the retention phase, a patient should be kept under regular control by attending follow-up appointments or via remote monitoring [2,3]. In the case of non-attendance at follow-up appointments and/or a lack of compliance with the doctor's recommendation, complications may occur, which, if left unattended, can lead to relapse of the malocclusion [4]. The most common complication in fixed orthodontic retention is composite islet debonding, which can occur, depending on the source, even in fifty percent of orthodontic patients during the retention phase [5]. It happens particularly often when a patient fails to attend follow-up appointments and the composite continues to wear when in contact with food [6]. Retainer breakage is less common, occurring more frequently with fiber-reinforced composite retainers [5]. The

rarest complication is the extreme displacement of anterior teeth to which a retainer is bonded. This was first described in case reports by Katsaros et al. [7] and Pazera et al. [8]. The etiology of this complication is based on a subtle, unvoluntary activation of the retainer wire, which is visible in the long term after the debonding of the fixed appliance [9]. There are several theories discussing the possible etiology of such complications. One theory suggests that the round wire becomes untwisted and acts on the teeth through the pressure of the unraveling (untwisted) braid steel links on the teeth [10], while another theory suggests activation due to wear of the wire caused by a partial loss of composite and exposure of the wire directly to the forces associated with everyday activities, such as clenching of the teeth or during food intake [11]. The latter theory assumes that if too much pressure is applied to the wire during bonding, the passivity of the round wire is lost, resulting in small forces being continuously transmitted to the teeth [12]. The constant action of retainer wire on the teeth causes them to move. Such displacement has been classified by Kucera et al. [13] into two different types, i.e., X effect change in torque between two adjacent teeth or the twist effect, which is when the opposite tipping of contralateral canines occurs with the torquing of the whole anterior segment. It has been documented that this problem may affect around a few percent of the whole orthodontic patient population [14] and primarily affects patients who have had a round stainless steel fixed retainer bonded, indicating that rectangular retainers are much more resistant to such an activation [12]. The aim of this case report was to present what happens to anterior teeth after fixed retainer removal and to analyze the structure of the fixed orthodontic retainer in patients suffering from the twist effect.

2. Case Presentation

The present case report follows the CARE statement [15]. A relevant checklist is attached to the manuscript as Supplementary Material S1.

2.1. Patient Characteristics

A 25-year-old female patient presented at an orthodontic consultation in the Department of Interdisciplinary Dentistry of Pomeranian Medical University in Szczecin. She was preoccupied with the position of her lower teeth, which is presented in Figure 1 (intraoral photographs), Figure 2 (extraoral photographs) and Figure 3 (intraoral scans). She reported having finished her orthodontic treatment ten years before the present appointment, and for many years, she did not arrive at the follow-up with her orthodontist, as the retainer held still in place. Intraorally Class I occlusion on molars and canines was diagnosed with a crossbite on endodontically treated 26. In both arches, the teeth were protruded. However, the patient underlined that she and her caretaker agreed to such an outcome during the previous treatment, as they wanted to avoid extractions at all costs. The anterior part of the lower arch presented as follows: there was a strongly proclined left canine with a marked apex palpable under the gingiva of the lingual side of the mandible. The left lateral and central incisors showed a decreasing proclination with a positive root torque, while the right central and lateral incisors were more retroclined and positioned more vertically to the alveolar process. Moreover, the right canine was positioned almost perpendicular to the alveolar process, with a negative root torque visible. There was a small amount of material remaining on the composite islets, where the retainer adhered to all teeth. A scale was present on the anterior teeth close to the retainer.

The patient was offered re-treatment with fixed orthodontics or several aligners. The patient declined, claiming as her reason the upcoming final examinations for the master's degree program she was attending, thus leaving her no time to undertake treatment. Therefore, a joint decision was made to remove the scale and retainer wire with the subsequent monitoring of progress through the superimposition of intraoral scans. The patient came six weeks later for the follow-up. As she also reported, the biggest change she noticed was within the lateral incisors. For the orthodontist, a change within the position of the

canines was also apparent. Figure 4 presents the intraoral photos, and Figure 5 presents the intraoral scans from the follow-up appointment.

Figure 1. Intraoral photographs at the first appointment.

Figure 2. Extraoral photographs at the first appointment.

Figure 3. Intraoral scans at the first appointment.

Figure 4. Intraoral photographs six weeks after fixed retainer removal.

Figure 5. Intraoral scans six weeks after fixed retainer removal.

2.2. Intraoral Scans and Superimposition

In order to thoroughly assess possible changes in the positions of the teeth, two intraoral scans were made using an iTero Element Flex intraoral scanner (iTero, Temple, AZ, USA), first during the first appointment (T1) after the retainer had been removed, and the second on the first follow-up appointment, six weeks later (T2), and a third scan was performed three months later (T3). The intraoral scans' superimposition was conducted using the best-fit algorithm in an external software (GOM Inspect, Zeiss, Germany) according to the protocol described by Jedliński et al. [16]. Figure 6 presents the measurements of tooth movement performed in GOM Inspect 2021 of the differences between T1 and T2.

The superimposition shows significant improvements in the position of the lateral incisors (tipping of tooth 32 by about 0.8 mm and tipping of tooth 42 by 0.7 mm) and the canines (tipping of tooth 33 by 0.4 mm, and on tooth 43, a correction of the crown position in the gingival area by 0.2 mm). No major differences were observed in the posterior segments of the lower arch. This indicates that the sole removal of the activated steel round retainer results in a partial self-correction of the twist effect of the teeth on which the retainer was located. The patient herself noticed the changes in tooth alignment and expressed that she was satisfied.

Figure 7 presents the measurements of tooth movement performed in GOM Inspect software of T1 and T3 scans' superimposition.

It is possible to note that the movement towards improvement of the position of the lateral incisors and canines is still taking place, but with less intensity (about 0.1 mm of difference in values of displacement T2-T3 per each point). Again, no major differences were observed in the posterior segments of the lower arch. It is therefore reasonable to expect that the trend of further improvement will continue.

(**A**)

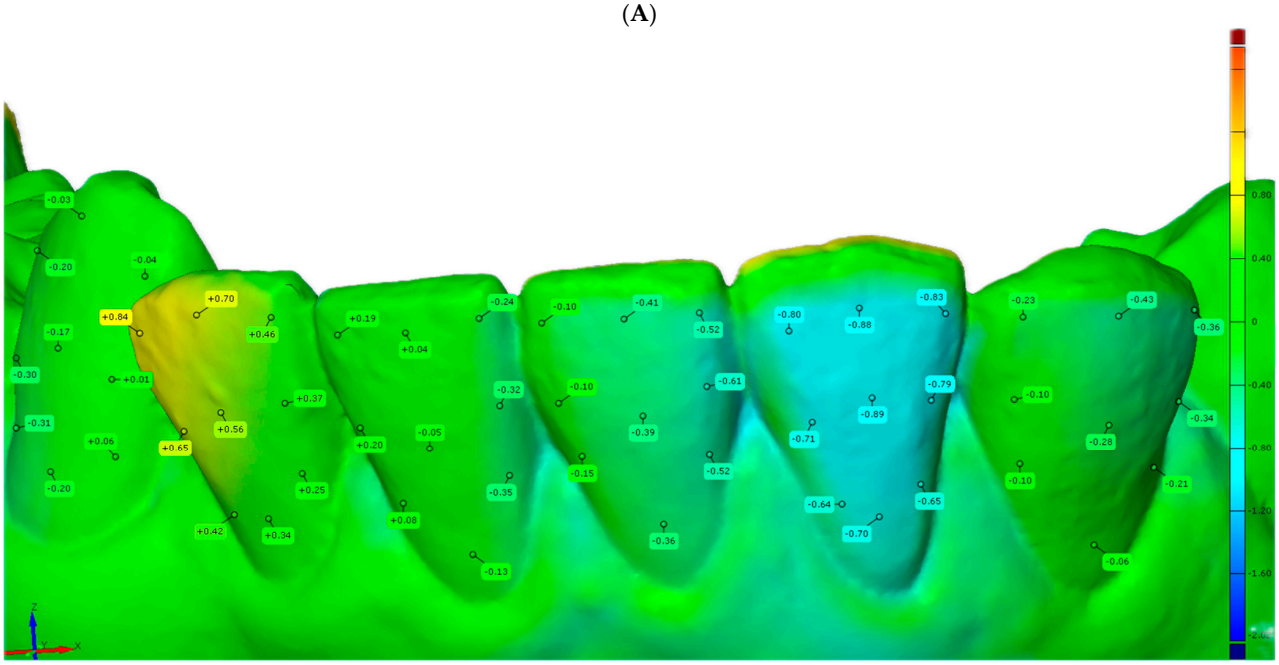
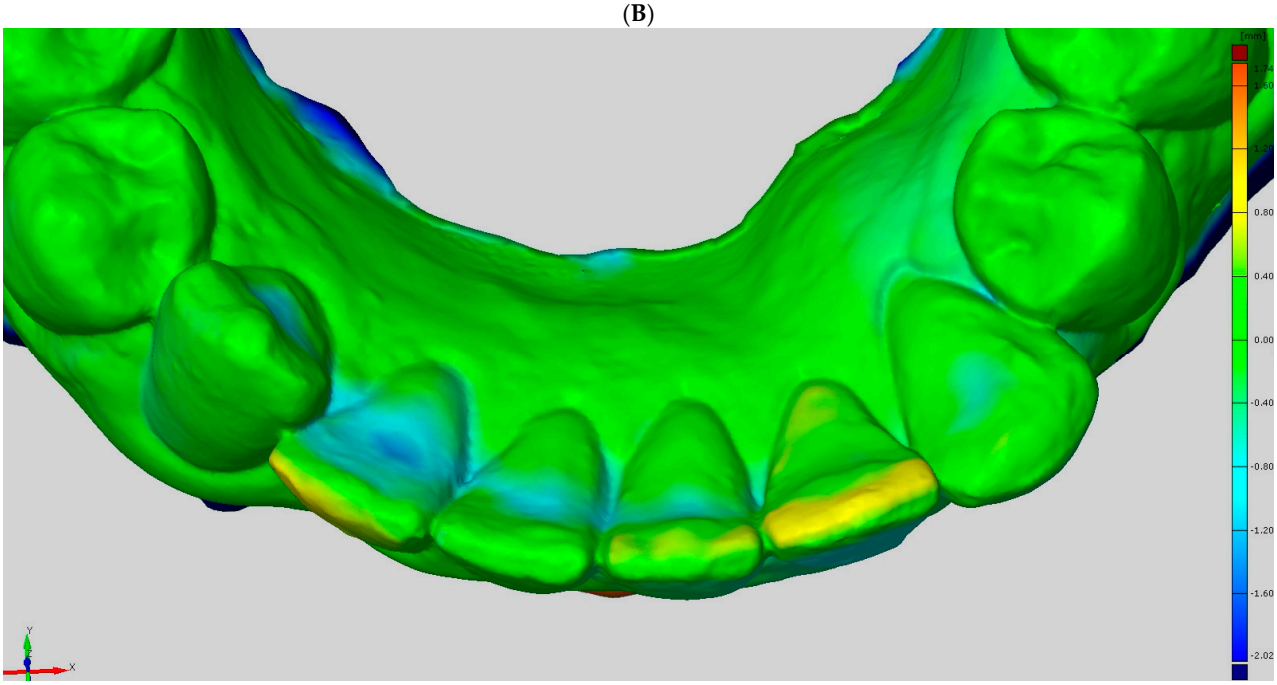


Figure 6. *Cont.*

(**B**)



(**C**)

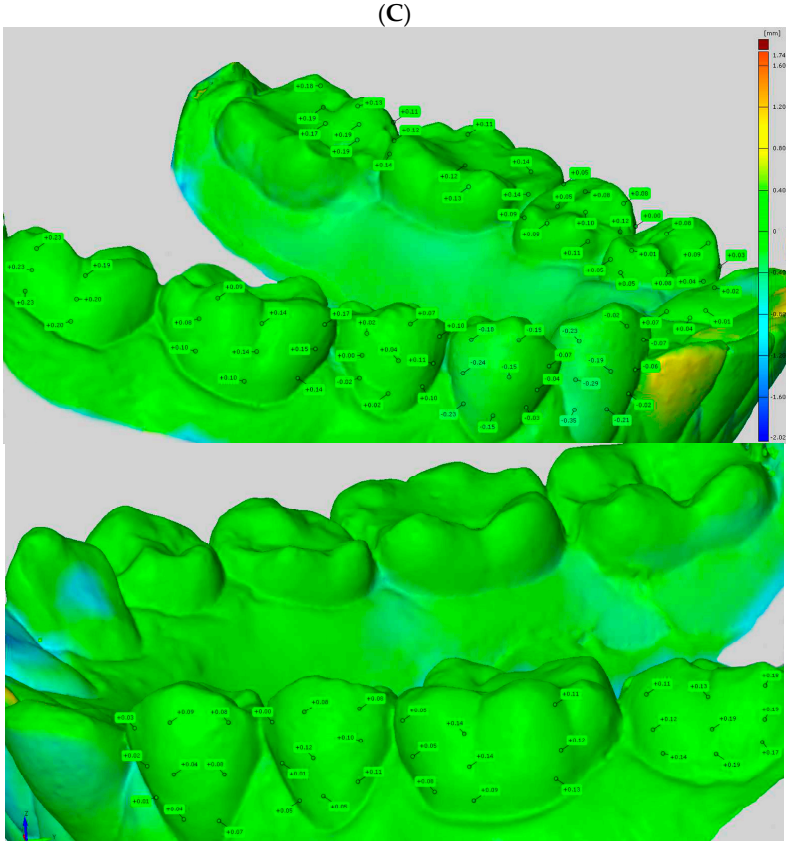
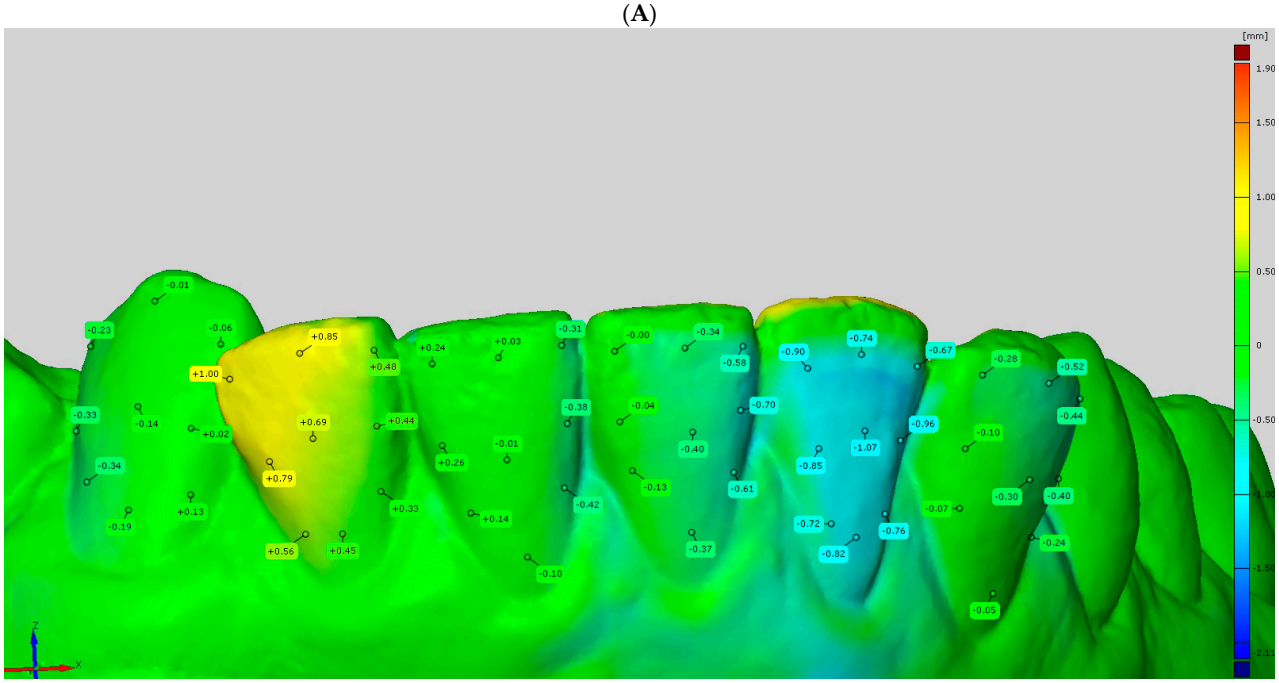


Figure 6. A three-dimensional assessment of the movements during the first six weeks on intraoral scan superimposition from (**A**) the buccal, (**B**) the occlusal perspective and (**C**) the lateral perspective.

(**A**)



(**B**)

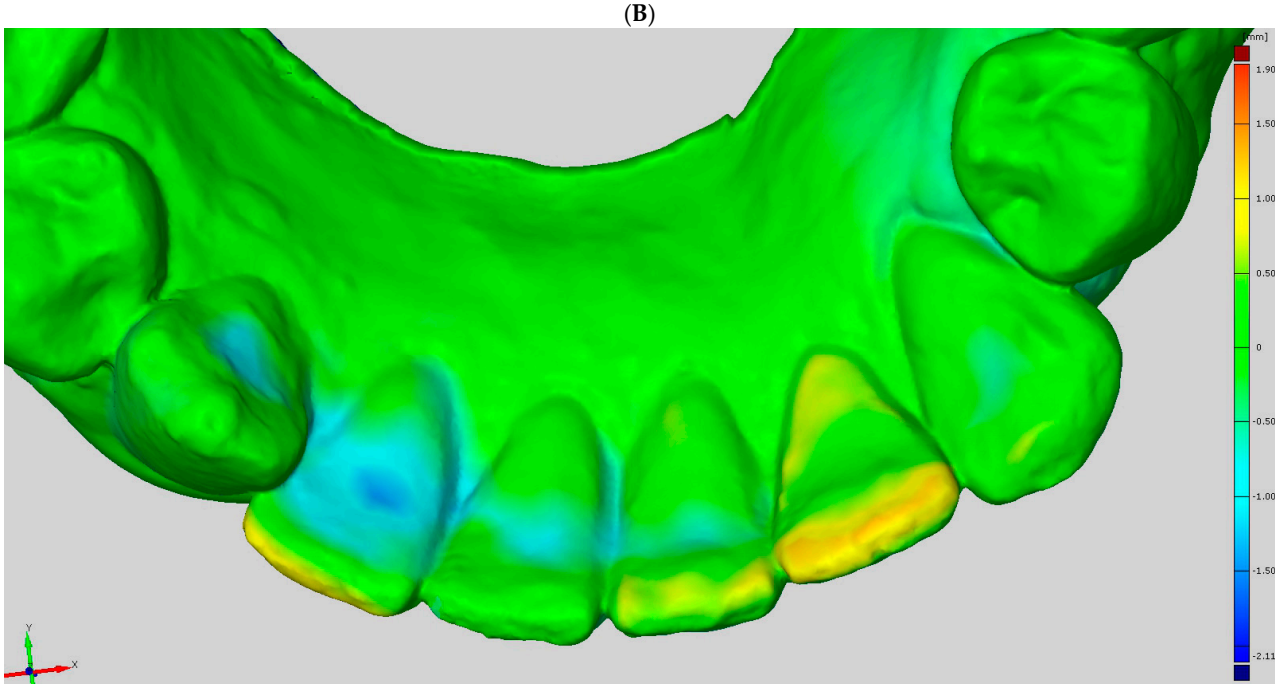


Figure 7. *Cont.*

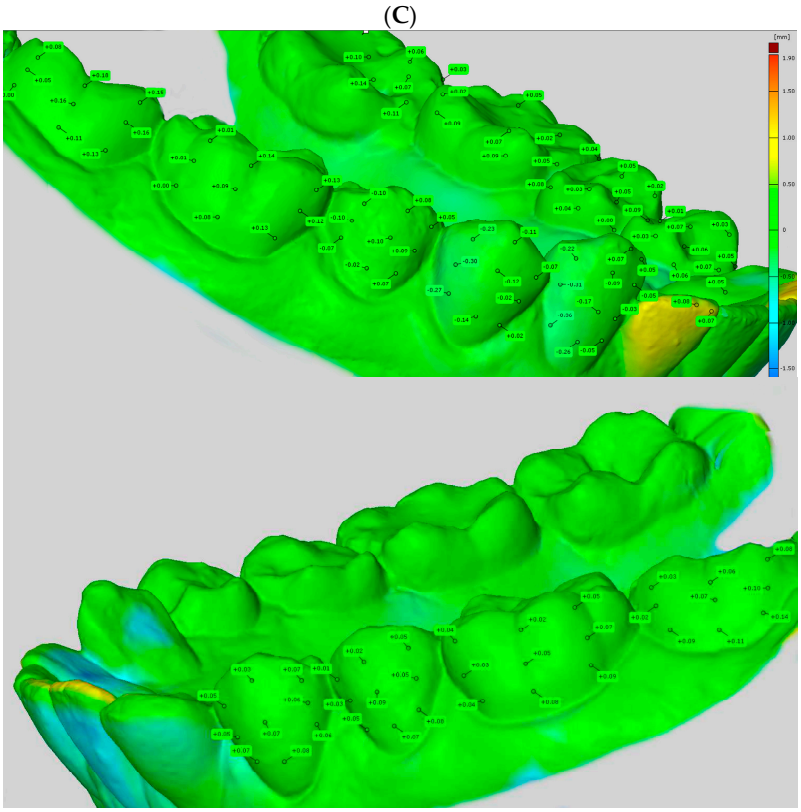


Figure 7. A three-dimensional assessment of the movements during three months on intraoral scan superimposition from (**A**) the buccal, (**B**) the occlusal perspective and (**C**) the lateral perspective.

2.3. Retainer Microscopic Analyses

To understand what changes may have occurred to the retainer and whether it may be responsible for the relapse of the malocclusion that has occurred, after removal, it was delivered to the laboratory of the Faculty of Mechanical Engineering at the Koszalin University of Technology. Measurements of the dimensions of the removed retainer in the patient were conducted using an Olympus OLS4000 confocal microscope (Olympus, Tokyo, Japan). With its advanced laser confocal microscopy capabilities, the microscope enabled us to delve into intricate structures of the study's sample. An z-axis resolution of 10 nm and an x-y resolution of 120 nm allowed for the visualization of minute details of the retainer. A series of images were captured in optical mode using a magnification of 5×. Subsequently, the diameters were determined at characteristic points of the orthodontic retainer in ten randomly chosen sections of the retainer, repeating the measurement five times in each section. The conducted measurements are presented in Figure 8.

It was observed that there were smaller diameters on the sections covered with the composite, while on the sections between the composite islets, the diameter values were larger and had a smaller scatter in the results. The largest diameter was found on the section without composite and was 0.445 mm. The smallest diameter was found on the section covered with the composite and was 0.391 mm. From this, it should be stated that the maximum difference between the diameters over the entire test section is 54 µm. If untwisting has occurred, it must have led to a simultaneous elongation of the wire. With a simplified analysis, and assuming that the wire is steel, the elongation is 183 µm. Compared to the tooth displacement values (around 2–3 mm), this is a completely different order of magnitude.

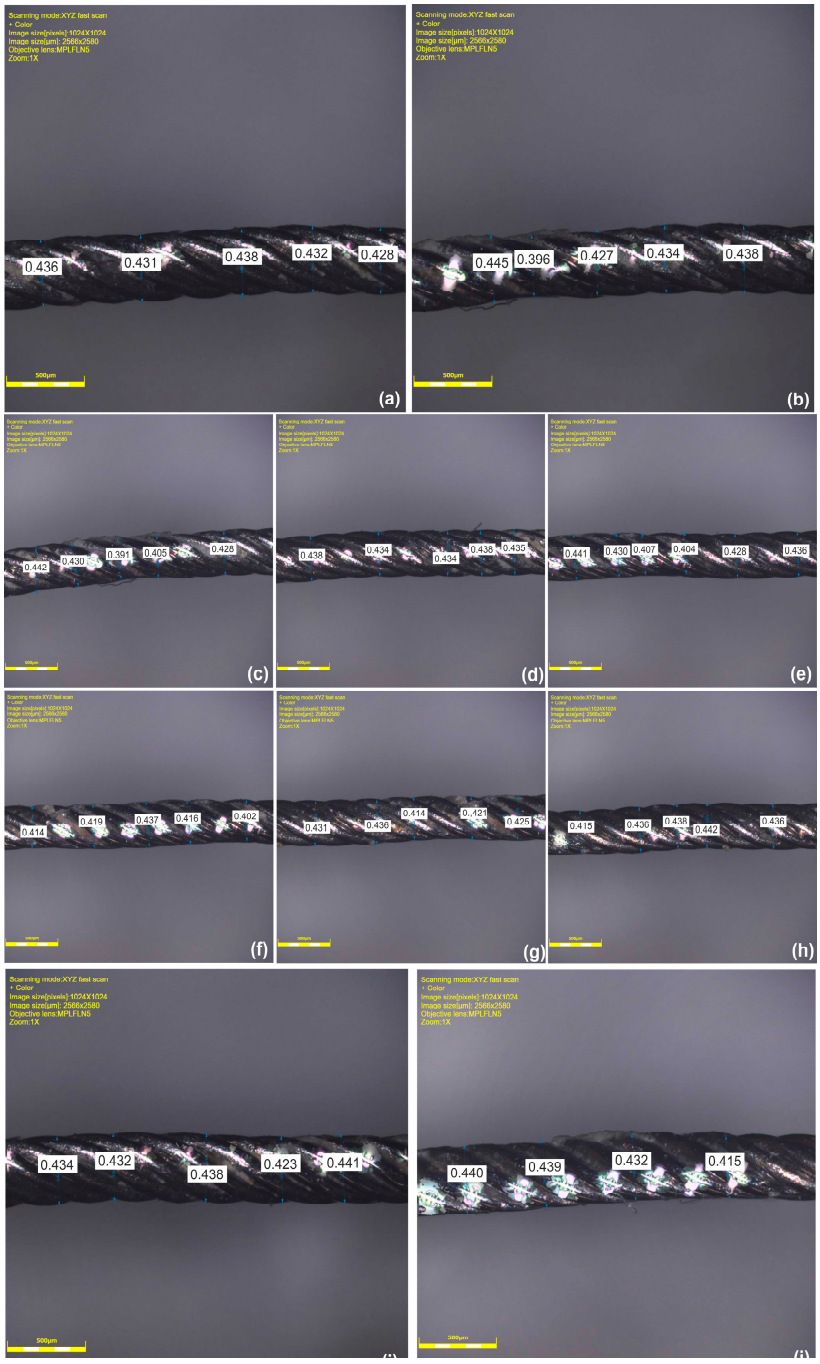


Figure 8. Measurements of retainer wire under laser confocal microscope.

3. Discussion

There are already published studies presenting the issue of the inadvertent displacement of teeth bonded to the round steel retainer [7,8,10,17,18] with different levels of severity, which were subsequently re-treated with fixed appliances. In one extreme case, the patient lost his lower left canine because of excessive negative torque of this tooth [19]. As the clinician was aware of the possible consequences of leaving an active retainer on the teeth, the wire was immediately removed to reduce its possible impact. In the present case, it was confirmed that minimal intervention causes a positive result in a very short time. The tooth movements observed on the scans are exactly the opposite of the displacement's characteristic for the twist effect. Furthermore, in the present case, the authors provided evidence that the twist effect did not originate from wire aging. Small deformations, which

were observed on the retainer wire, are very unlikely to cause a tooth displacement of this size. This rejects the hypothesis that with round fixed retainers, such a reaction is inevitable. However, it may seem interesting that a steel retainer wire covered with composite seems to be more robust to changes in diameter. This stands with the line the report of Tee et al. [20], which reported that a larger coverage of wire with composite enhances the resistance of the wire to failure. It is also vital that if the most common fixed retention failure—adhesive failure—needs to be addressed, the retainer should be passively placed on the tooth and covered with composit rather than pressed or embedded into the composite with a hand tool or tied firmly with a metal ligature. The latter technique may potentially result in an activation of the retainer wire [9].

Furthermore, such complications can be prevented by double retention [4,16], which can be achieved through the "cage effect" of removable thermoformable splints [21]; however, increased cooperation from the patient is necessary in attending follow-up appointments and replacing the retainer if the plastic wears off.

Finally, it should be underlined that both patients and dentists, and not only orthodontists, should be aware that such problem may arise during orthodontic retention and should thus feel responsible for tooth position monitoring, and if in doubt, they should consult an orthodontist immediately [22,23]. This is even more important as the patient may demonstrate early symptoms of wire syndrome as root prominence on the gingiva [24].

The limitations of the present study arise from the fact that the twist effect of a fixed retainer is a rather rare complication, and it is difficult to find a proper study group, which would allow for this phenomenon to be investigated on a larger sample. Moreover, it would be useful to extend the follow-up of the patient in order to observe the changes within the anterior segment of the mandible. In addition, although the patient claimed that the teeth were perfectly aligned at the end of the fixed orthodontic treatment, the achieved tooth position remained unknown.

4. Conclusions

This case report is the first to provide quantitative evidence of the structural changes in a retainer that cause wire syndrome, as well as tooth displacement, after the removal of the activated retainer. The following conclusions can be drawn:

1. The presented case report indicates that there is always a need to remove a fixed retainer when a twist effect is diagnosed. Even if the patient does not consider retreatment in the near future, the removal of the fixed retainer will cause a spontaneous partial correction. Furthermore, the lack of force on the teeth will prevent further worsening and subsequent complications.
2. The sections of wire covered with composite are less likely to untwist in the future. In the presented case, the changes in the dimensions of the round retainer wire could not have led to such significant changes in the teeth's positions.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/app14093889/s1, Care Checklist S1.

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Informed Consent Statement: Informed consent was obtained from the patient described in this study.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Inchingolo, F.; Inchingolo, A.M.; Ceci, S.; Carpentiere, V.; Garibaldi, M.; Riccaldo, L.; Di Venere, D.; Inchingolo, A.D.; Malcangi, G.; Palermo, A.; et al. Orthodontic Relapse after Fixed or Removable Retention Devices: A Systematic Review. *Appl. Sci.* **2023**, *13*, 11442. [CrossRef]
2. Jedliński, M.; Mazur, M.; Schmeidl, K.; Grocholewicz, K.; Ardan, R.; Janiszewska-Olszowska, J. Orthodontic Retention-Protocols and Materials-A Questionnaire Pilot Study among Polish Practitioners. *Materials* **2022**, *15*, 666. [CrossRef]
3. Sangalli, L.; Savoldi, F.; Dalessandri, D.; Visconti, L.; Massetti, F.; Bonetti, S. Remote Digital Monitoring during the Retention Phase of Orthodontic Treatment: A Prospective Feasibility Study. *Korean J. Orthod.* **2022**, *52*, 123–130. [CrossRef]
4. Wolf, M.; Schulte, U.; Küpper, K.; Bourauel, C.; Keilig, L.; Papageorgiou, S.N.; Dirk, C.; Kirschneck, C.; Daratsianos, N.; Jäger, A. Post-treatment changes in permanent retention. *J. Orofac. Orthop.* **2016**, *77*, 446–453. [CrossRef]
5. Jedliński, M.; Grocholewicz, K.; Mazur, M.; Janiszewska-Olszowska, J. What Causes Failure of Fixed Orthodontic Retention?—Systematic Review and Meta-Analysis of Clinical Studies. *Head Face Med.* **2021**, *17*, 32. [CrossRef]
6. Bearn, D.R. Bonded Orthodontic Retainers: A Review. *Am. J. Orthod. Dentofac. Orthop.* **1995**, *108*, 207–213. [CrossRef]
7. Katsaros, C.; Livas, C.; Renkema, A.M. Unexpected complications of bonded mandibular lingual retainers. *Am. J. Orthod. Dentofac. Orthop.* **2007**, *132*, 838–841. [CrossRef] [PubMed]
8. Pazera, P.; Fudalej, P.; Katsaros, C. Severe Complication of a Bonded Mandibular Lingual Retainer. *Am. J. Orthod. Dentofac. Orthop.* **2012**, *142*, 406–409. [CrossRef] [PubMed]
9. Charavet, C.; Vives, F.; Aroca, S.; Dridi, S.-M. "Wire Syndrome" Following Bonded Orthodontic Retainers: A Systematic Review of the Literature. *Healthcare* **2022**, *10*, 379. [CrossRef]
10. Shaughnessy, T.G.; Proffit, W.R.; Samara, S.A. Inadvertent Tooth Movement with Fixed Lingual Retainers. *Am. J. Orthod. Dentofac. Orthop.* **2016**, *149*, 277–286. [CrossRef]
11. Sifakakis, I.; Pandis, N.; Eliades, T.; Makou, M.; Katsaros, C.; Bourauel, C. In-Vitro Assessment of the Forces Generated by Lingual Fixed Retainers. *Am. J. Orthod. Dentofac. Orthop.* **2011**, *139*, 44–48. [CrossRef] [PubMed]
12. Arnold, D.T.; Dalstra, M.; Verna, C. Torque resistance of different stainless steel wires commonly used for fixed retainers in orthodontics. *J. Orthod.* **2016**, *43*, 121–129. [CrossRef] [PubMed]
13. Kučera, J.; Littlewood, S.J.; Marek, I. Fixed Retention: Pitfalls and Complications. *Br. Dent. J.* **2021**, *230*, 703–708. [CrossRef]
14. Renkema, A.M.; Renkema, A.; Bronkhorst, E.; Katsaros, C. Long-term effectiveness of canine-to-canine bonded flexible spiral wire lingual retainers. *Am. J. Orthod. Dentofac. Orthop.* **2011**, *139*, 614–621. [CrossRef] [PubMed]
15. Riley, D.S.; Barber, M.S.; Kienle, G.S.; Aronson, J.K.; von Schoen-Angerer, T.; Tugwell, P.; Kiene, H.; Helfand, M.; Altman, D.G.; Sox, H.; et al. CARE Guidelines for Case Reports: Explanation and Elaboration Document. *J. Clin. Epidemiol.* **2017**, *89*, 218–235. [CrossRef] [PubMed]
16. Jedliński, M.; Tandecka, K.; Grocholewicz, K.; Janiszewska-Olszowska, J. Three-Dimensional Microanalysis of Tooth Movement during the First 6 Months of Orthodontic Double Retention. *Am. J. Orthod. Dentofac. Orthop.* **2024**, *165*, 143–160. [CrossRef]
17. Sfondrini, M.F.; Pascadopoli, M.; Beccari, S.; Beccari, G.; Rizzi, C.; Gandini, P.; Scribante, A. Orthodontic Fixed Retainer and Unwanted Movements of Lower Anterior Teeth: A Case Report. *Case Rep. Dent.* **2022**, *2022*, e3100360. [CrossRef]
18. Steegmans, P.A.J.; Jonkman, R.E.G.; De Lange, J. Fixed Flexible Spiral Wire Retainers and Unwanted Tooth Movements: A Case Report. *Appl. Sci.* **2023**, *13*, 922. [CrossRef]
19. Singh, P. Canine Avulsion: An Extreme Complication of a Fixed Mandibular Lingual Retainer. *Am. J. Orthod. Dentofac. Orthop.* **2021**, *160*, 473–477. [CrossRef]
20. Tee, S.H.M.; Shahid, S.; Al-Moghrabi, D.; Fleming, P.S. An Assessment of the Impact of Adhesive Coverage and Wire Type on Fixed Retainer Failures and Force Propagation along Two Types of Orthodontic Retainer Wires: An in Vitro Study. *Angle Orthod.* **2023**, *93*, 712–720. [CrossRef]
21. Jacobson, A. The Essix Appliance Technology: Applications, Fabrication and Rationale: J. J. Sheridan, K. Hillard, and P. Armbruster CTAC International, Inc; 2003; 130 Pages; $82.50. *Am. J. Orthod. Dentofac. Orthop.* **2003**, *124*, 749. [CrossRef]
22. Mollov, N.D.; Lindauer, S.J.; Best, A.M.; Shroff, B.; Tufekci, E. Patient attitudes toward retention and perceptions of treatment success. *Angle Orthod.* **2010**, *80*, 468–473. [CrossRef] [PubMed] [PubMed Central]
23. Molyneaux, C.; Sandy, J.R.; Ireland, A.J. Orthodontic Retention and the Role of the General Dental Practitioner. *Br. Dent. J.* **2021**, *230*, 753–757. [CrossRef] [PubMed]
24. Charavet, C.; Israël, N.; Vives, F.; Dridi, S.-M. Importance of Early Detection of Wire Syndrome: A Case Series Illustrating the Main Stages of the Clinical Gradient. *Clin. Pract.* **2023**, *13*, 1100–1110. [CrossRef] [PubMed]