

Alignment of a Vertical Migrated Periodontal Pre-injured Upper Central Incisor

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Abstract

Introduction: Labial and vertical migration of maxillary incisors is a common complication of moderate to severe periodontitis and it is often the motivation for patients to seek periodontal and orthodontic treatment. **Aims:** This case report demonstrates a minimal invasive orthodontic therapy with modified aligners to straighten a periodontal pre-injured upper central incisor with sophisticated bone defect. **Methods:** A female patient, aged 36 years, presented in our department with the chief complaint of elongation and protrusion of her right upper central incisor, which had strongly changed its position within at least the last year on account of a sophisticated periodontal injury and it had already been incisal grinded by her general dentist up to the exposure of dentin. The clinical evaluation revealed a vertical divergence and protrusion of 2 mm, respectively, frontal dental crowding, and distinctive vertical bone loss with probing depth of at least 8 mm at the most affected side, mild loosening, but no signs of periodontal inflammation. A minimal invasive treatment with a modified aligner appliance, including a total of 3 aligner series and 6 set-ups, was carried out. Intrusion was realized with vertical elastic, little buttons bonded at the aligner and an incisal slot opening. **Results:** Total treatment time amounted 6 months. The result was stabilized with a bonded retainer. Radiologic control revealed no variation in tooth length and a stable periodontal pocket after active orthodontic treatment. **Discussion and conclusion:** This case report demonstrates that orthodontic aligner treatment in the aesthetical area is possible and can be safely performed even in case of distinctive bone loss.

Key Words: Pathologic tooth migration, Aligner, Bonded button, Periodontics, Orthodontics

Introduction

Pathologic tooth migration is a common finding in periodontal patients [1,2] with a high prevalence reported to be up to 55.8% [3] and it is positive correlated with the severity of the periodontal disease [4]. On account of attachment loss and loss of periodontal support an over-eruption, protrusion and flaring of upper front teeth [3,5,6] and open gingival embrasures, “black triangles” [7], are a very common clinical finding, which can significantly influence the individual well-being with a negative impact on health related quality of life [8-10]. These symptoms are often part of the patient’s chief complaint [1], motivating to commence periodontal and also orthodontic treatment. Basically, there are no exact metric limits in terms of probing depth or loss of periodontal attachment up to which orthodontic tooth movement is possible [11], but infrabony pockets and reduced alveolar bone height can complicate orthodontic therapy. The apical shift of the centre of resistance within a reduced periodontium necessitates an individual adaption of the biomechanics [11,12]. The force systems must be adequately reduced according to the decreased attachment level in order to avoid resorption and further bone loss [13]. For an aesthetic rehabilitation and alignment, orthodontic intrusion with light forces (5-15 g) has been reported to be used successfully to treat extrusion and flaring of migrated teeth [12]. In this context, the possibility of new attachment [1,12], which can contribute to reduce gingival embrasures [14,15] has also been suggested, if inflammation is controlled during all phases of orthodontic therapy [3,11,12,16].

Aims

This case report demonstrates a successful minimal invasive orthodontic treatment with modified aligners for intrusion and

retraction of a periodontal pre-injured upper central incisor with sophisticated bone defect.

Case Report

A 36-year old female patient in good general health presented in our Department of Orthodontics with the chief complaint of aesthetic impairment due to an elongation and protrusion of her right upper central incisor, which incisal edge had already been reduced by her general dentist up to the exposure of dentin, but performed ongoing shifting, mainly observed during the last year by the reason of reduced periodontal anchorage and extensive bone loss. The patients’ medical history was inconspicuous. She reported an orthodontic treatment in her youth with alignment of the formerly severe crowded upper incisors and later on, a periodontal disease at her right upper central incisor which had been treated 10 years ago by her general dentist with a stable result and so far no complications during the recall-intervals of twice a year.

The clinical evaluation revealed a vertical divergence and protrusion of the right upper central incisor in comparison to the contralateral side of 2 mm, respectively, combined with mild frontal dental crowding, stable class I molar relationship, no midline shift and no functional overload present. Sensitivity testing with cold was positive and a mild loosening (mobility grad I) could be observed. The periodontal status showed exposure of the cemento-enamel junction, a localized distinctive bone loss around the right upper central incisor with probing depth of at least 8 mm at the most affected side, no signs of current periodontal inflammation present (BOP = bleeding on probing = 0), an open gingival embrasure between the upper central incisors, and a high level of general oral hygiene (*Figure 1*). The periapical radiographic image showed an isolated horizontal and vertical bone defect with circular extension at the palatal side of the right upper central

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incisor and no signs of periapical infection (*Figure 2*). Additionally, a microdontia of the right upper lateral incisor with distal spacing was present (*Figure 1*). Model casts were fabricated for tooth discrepancy measurements, space analysis and treatment planning.



Figure 1. Initial pre-treatment intraoral photographs, illustrating an overeruption and protrusion of the right upper central incisor due to pathologic tooth migration.

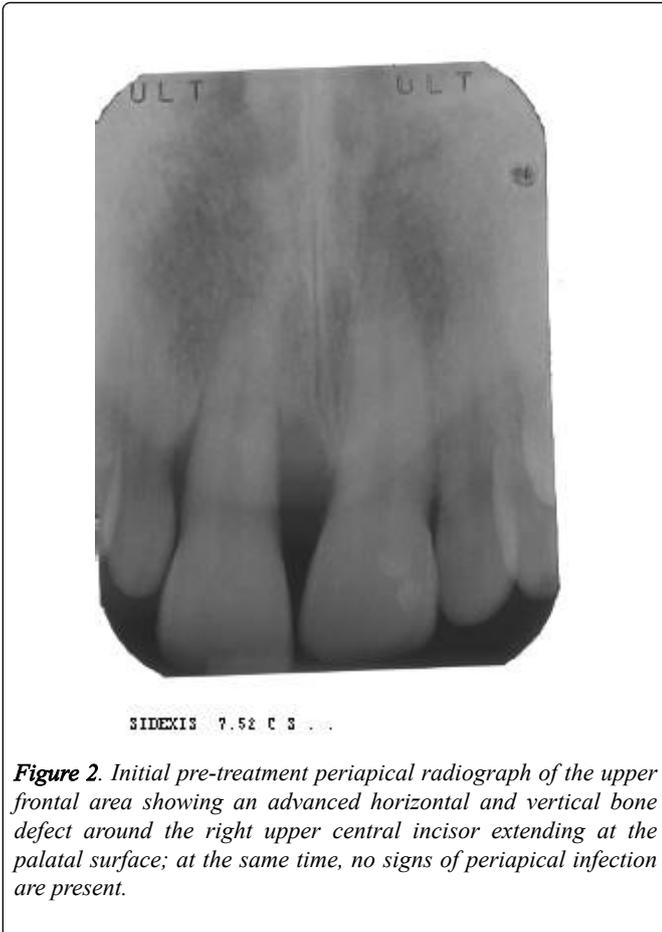


Figure 2. Initial pre-treatment periapical radiograph of the upper frontal area showing an advanced horizontal and vertical bone defect around the right upper central incisor extending at the palatal surface; at the same time, no signs of periapical infection are present.

After previous periodontal therapy and recall by her general dentist, to proof the absence of inflammatory processes, a minimal invasive treatment with a modified aligner appliance was carried out to guarantee high aesthetics, unlimited oral dental hygiene, and at once splinting of the periodontal pre-injured tooth during orthodontic alignment.

The patient got a detailed explanation about the planned treatment, possible complications and prognosis and the treatment alternatives. A written informed consent was obtained from the patient prior to initiation of the therapy, and periodontal recalls at short intervals were carried out by her general dentist during the active orthodontic treatment to guarantee that no periodontal inflammation was present.

The treatment included a total of 3 aligner series, in each case of 0.5 mm, 0.6 mm and 0.8 mm thickness (ERKODUR clear, Thermoforming foils and discs, ERKODENT®, Erkodent Erick Kopp GmbH, Pfalzgrafenweiler, Germany), and a total of 6 set-ups. Therefore, alginate impressions of the upper jaw were taken (TETRACHROM, quickly setting alginate and Rim-lock impression trays, KANIEDENTA, Herford, Germany). For manufacturing of each aligner series, dental model casts were fabricated (dental plaster type IV, super-hard; Dr. Böhme and Schöps Dental GmbH, Goslar, Germany) and a dental technical set up was performed, respectively, which was adjusted to the achieved and corresponding treatment steps. Spacing of the right upper lateral incisor permitted a space acquisition for the retraction of the central incisor, so that its position could successively be improved in the set-up. The intrusion was realized due to an incisal slot opening in the aligner. Power transmission was implemented using vertical elastic (1/4 inch light, 6.4 mm diameter, 0.7 N, 71 g, Dentaureum GmbH & Co. KG, Ispringen, Germany), which could be fastened at little buttons bonded at the buccal and palatal surface of the aligner using the Mini-mold™ kit (smile dental Handelsgesellschaft GmbH, Ratingen, Germany), a clear aligner adhesive for thermoplastic aligners (BOND Aligner™, Reliance Orthodontic Products, Inc., Itasca, Illinois, USA) and a light curing composite (Alpha-Flow® Light Cure Flowlabel Composite, DENTAL TECHNOLOGIES, Inc., Lincolnwood, Illinois, USA) (*Figure 3*). Intrusion force amounted less than 10 g. Wearing time of each aligner was approximately 2-3 weeks, 24 hours a day, excluding tooth-cleaning and nutrition. Total treatment time amounted 6 months with recalls every 4-6 weeks to control the fitting of the aligner, the gingival and periodontal conditions, tooth mobility and force applied on the right upper central incisor as well as the transfer of the set up. The first aligner series was fabricated with an incisal slot opening for intrusion of the right upper central incisor and at the same time distal movement of the right upper lateral incisor to gain space for the movement of the central incisor as well as slight derotation of the upper left central incisor (*Figure 4*). The second aligner series was constructed with full incisal coverage and focused on the palatal movement of the right upper central incisor. The third aligner series realized the final buccal-palatal correction to level the right upper lateral and central incisors. Therefore, in the setup, the aligner was spared at the palatal tooth surface and additionally a power point was applied at the buccal surface of the aligner with a special dental plier for forming bumps (*Figure 5*). Intraoral photographs, study casts and standardized periapical radiographs of the maxillary anterior teeth were performed initially and after conclusion of the active orthodontic treatment. The clinical situation, also verified by model casts, revealed a stable upper frontal tooth position during all recalls up to 20 month post-control (*Figures 6-8*). During the whole treatment time, the periodontal status was controlled regularly

and if necessary, professional cleaning was performed by the general dentist to maintain stable periodontal conditions without inflammation. Clinical attachment level was measured with a periodontal probe at the same time intervals. Inflammation was recorded subjectively by the same operator

on the basis of gingival appearance, BOP and periodontal probing depth. All measurements were carried out by the same clinical observer. Changes in bone level were also evaluated by 2D overlapping of radiographic images.

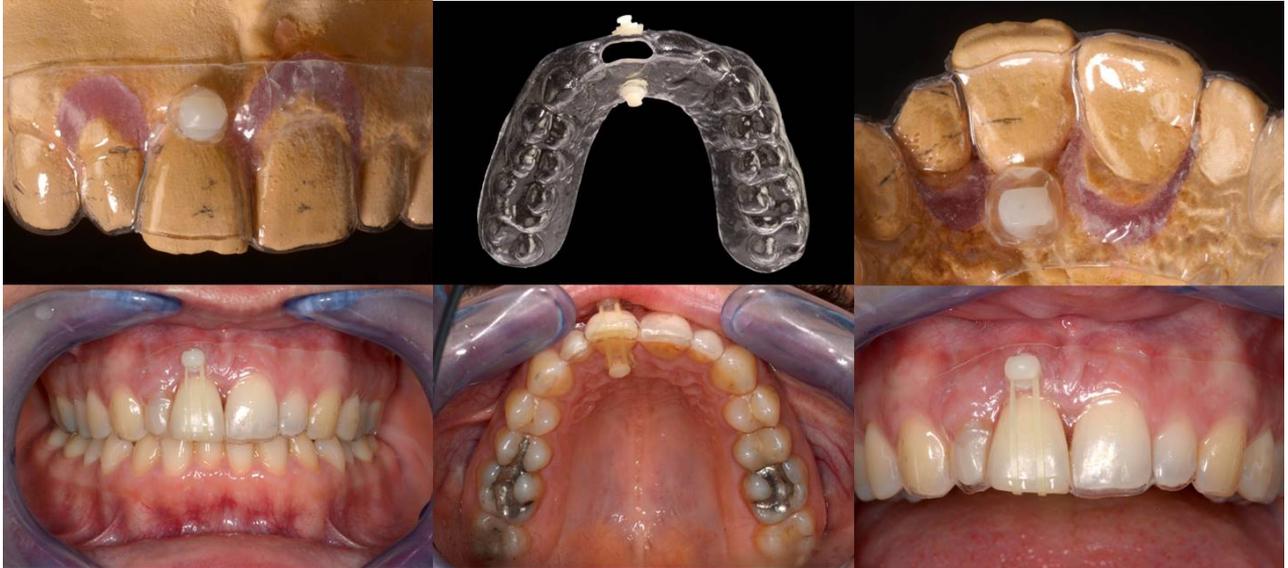


Figure 3. Modified aligner appliance with incisal slot opening and buttons bonded at the buccal and palatal surface for bodily intrusion of the right upper central incisor with vertical elastics (first aligner series, 0.5 mm thickness).



Figure 4. Intraoral photographs after transfer of the first set up. Clinical crown length and soft tissue conditions could already be improved. Black triangle decreased and cemento-enamel junction is not exposed anymore.



Figure 5. Model casts and set up for the fabrication of the third aligner series with spared palatal side and buccal power point facilitating bucco-palatal correction of the right upper central incisor.



Figure 6. Intraoral photographs after transfer of the set-up of the third aligner series during the 3 month retention recall, showing good alignment of the upper front teeth, no gingival inflammation present and black triangle essentially improved.

The orthodontic treatment outcome was stabilized with a bonded retainer (dentaflex® straight wires, rund, 6-strand “co-axial”, hard plus, 0.38 mm diameter, 0.175 Inch, DENTAURUM GmbH & Co. KG, Ispringen, Germany; Alpha-Flow® Light Cure Flowabel Composite, DENTAL TECHNOLOGIES, Inc., Lincolnwood, Illinois, USA), and an additional aligner (ERKODUR clear, 1.0 mm thickness, Thermoforming foils and discs, ERKODENT®, Erkodent Erick Kopp GmbH, Pfalzgrafenweiler, Germany), which was spared at the palatal side, was also adjusted for retention, and instructed to be worn during the night-time (Figure 8). After conclusion of the active orthodontic treatment, recalls were performed every 3 month up to one year post-control.

Clinical conditions 7 month after conclusion of the active orthodontic treatment, showed a closure of gingival embrasures due to intrusion. However, gingival papilla did not completely fill the interdental space (Figure 7). No signs of microbiological reinfection, inflammation or loosening or any further progress of periodontal destruction, indicated by stable probing depth, were present. The periapical radiograph, taken after conclusion of the active orthodontic treatment revealed stable periodontal conditions and no further bone loss (Figure 9). Post-treatment, crown morphology-reshaping was planned to be performed by prosthetic restoration with a ceramic veneer to improve the aesthetic appearance of the right upper lateral incisor.



Figure 7. Intraoral photographs 7 month post-control illustrating a stable class I molar relationship and front tooth position with no gingival inflammation present.



Figure 8. Intraoral photographs 11 month post-control and 1 month after insertion of the bonded retainer.

Discussion

Periodontal bone loss and pressure produced by the inflammatory tissues within periodontal pockets appears to be a major factor in the etiology of pathologic tooth migration [3,17] of which extrusion is a common form [3]. By the reason that anterior teeth are not protected by occlusal forces and have no anterior-posterior contacts to inhibit tooth migration [12] divergences as elongation are predominantly found in the maxillary anterior area [18]. Although, in the literature a spontaneous correction of migrated teeth is reported to occur after surgical and non-surgical periodontal therapy [17,19], and in individual cases after decline of

inflammation, usually, a multidisciplinary approach including periodontal, orthodontic, restorative and/ or prosthetic treatment is required to manage these complications [1-3,20]. Furthermore, spontaneous corrections are most frequently reported to occur sometimes and in early stages of pathologic tooth migration after periodontal therapy [3] and in cases of facial flaring and upper frontal spacing [17,19]. In contrast, in cases of severely pathologic overerupted maxillary central incisors, a spontaneous correction after periodontal therapy could not be found in the literature.



Figure 9. Post-treatment periapical radiograph of the upper front tooth area with no signs of apical inflammation. Infrabony defect seems to be stable but no attachment gain is measurable.

Those teeth not only lead to disfiguration of the patient [3,17] but their undesirable vertical movement can also interfere functional occlusion [21], which otherwise leads to traumatic occlusal overload of periodontal tissue and may additionally promote periodontal destruction [22-24]. Hence, in addition to periodontal treatment, incisal adjustment is often the first procedure to overcome these symptoms [17]. Unfortunately, this method had not been successful in our case due to ongoing eruption and exposure of dentin. It should be mentioned that many factors may also influence tooth migration [3], which might have additionally contributed to the ongoing extrusion of the right upper incisor observed in our patient. For example, soft tissue forces of the tongue, cheek and lips can move teeth, especially after loss of periodontal support [18,25] when the equilibrium of these interactive forces is disturbed [26].

By the risk of dentin sensitivity after further incisal grinding or exposed root surface due to overeruption [21], further occlusal reduction was not recommended. In addition, prosthodontic correction of vertical tooth movement can also be a treatment option, but due to the risk of pulp exposure, loss of tooth vitality with the need of endodontic treatment or in case of less preparation, interference of the anterior path of guidance, occlusal trauma of other teeth that may occlude with them, and compromised aesthetics [21], it is usually not the treatment of choice.

An alternative treatment option and often the first treatment of choice in cases with no caries or fillings present, is an orthodontic correction of migrated teeth [15,16], and light intrusive forces are reported to be used successfully to correct extrusion and flaring forms of pathologic tooth migration [3,12]. Histologic material from *Macaca fascicularis* monkeys with experimentally induced periodontal defects and intrusion of incisors into these infrabony defects also suggested the possibility of new attachment [27]. In this context, the absence of gingival inflammation is an essential precondition to avoid periodontal tissue break down and to gain new attachment [12,16,27].

Usually, orthodontic therapy following a periodontal treatment involves fixed sectional orthodontic appliances for maximum control of tooth movement [2,3]. Inflammatory destruction of the supporting hard and soft tissue followed by reduced bone height often limits dental tooth movement due to displacement of the center of resistance [13]. These properties are especially important considering teeth with severe periodontal injury, mobility and large vertical bone loss, where the center of resistance has moved far apically [24] and the tooth movement with fixed orthodontic appliances is limited because of the risk of tipping and tilting by inadequate moment to force ratio [28].

In this regard, the observations made by Nelson et al. are very important. They noted a positive correlation between alveolar bone loss of maxillary anterior teeth in adult orthodontic patients after tooth movement and advanced age, whereas no correlation between bone loss and length of orthodontic treatment, post-treatment gingival appearance and amount of horizontal and vertical tooth movement could be found [29].

In the case presented, the bone defect at the right upper central incisor, measured with a periodontal probe, amounted 8 mm at the mesial and 5 mm at the distal side, and periapical radiographs revealed an even greater bone defect extending at the palatal surface.

Nowadays, aligners can be more and more considered as an effective alternative compared to fixed orthodontic appliances. They are a preferable treatment option in the periodontal pre-injured dentition, because of their inconspicuousness, splinting of loosened teeth and the possibility of unlimited oral hygiene. With aligners teeth are bodily splinted [18] and tooth movement can be reduced to minimal steps predetermined by the set up. In a case study, Lee et al. could already demonstrate a successful orthodontic treatment of maxillary anterior pathologic tooth migration with clear aligners, and revealed an improvement of the clinical parameters (probing depth, gingival recession, mobility, and esthetics) and a reduction of the radiographic infrabony defects [18]. Nevertheless, bone filling after orthodontic correction was considered controversial in this report.

After considering the patients history, the quality and height of remaining bone level and the cooperation of the patient, we decided to use a modified aligner appliance to realize repositioning of the overerupted and proclined right upper central incisor. As the patient denied an overall treatment and no functional overload was present at the beginning of the

treatment as well as in the final set up, the lower arch crowding was not included in the treatment plan.

Diedrich noted that, on account of few, cell-poor cortical bone within periodontal pre-injured teeth, the remaining bone segments have less potential for remodeling, and therefore a time delay in biological reactions during orthodontic therapy should be taken into account [11,13,20]. Hence, diminished resorptive bone surface necessitates a reduction in the magnitude of force applied and biomechanics have to be adapted, which are key factors for a traumatic tooth movement in the periodontal pre-injured dentition [13]. Melsen et al. also mentioned that light continuous forces are required for optimal bone remodeling and intrusion, not to stress the periodontal ligament and to avoid hyalinization which otherwise may allow epithelial downward growth that hinder the formation of new connective tissue attachment [27]. Moreover, bodily intrusion in an apical direction should be intended, because new attachment can only be formed by periodontal ligament cells which are most coronal situated and cannot be optimally stimulated, if tipping forces are present [27].

It should be mentioned that light continuous forces can also be achieved with aligner treatment, if the wearing time is not interrupted, and in addition, tipping during intrusion can be avoided by bodily splinting with aligners, so that the above mentioned preconditions can successfully be fulfilled. Furthermore, with the modification of the first aligner series (with an incisal slot opening) and the intrusion mechanics used here, the force applied directly passed through the center of resistance, so that a bodily intrusion could be easily realized and tipping moments could be avoided. In our case, the aligner treatment greatly facilitated the treatment outcome. With this treatment method the tooth movement could be reduced to minimal amounts, adjusted to the reduced bone level and periodontal support. According to Lee et al. who applied a 0.5 mm thick aligner for the correction of maxillary pathologic tooth migration in the periodontal pre-injured dentition for the first week, followed by a 0.75 mm thick aligner for 2 weeks, correlating to a gradual tooth movement of 1 mm [18], we reduced the tooth movement by using 0.5 mm, 0.6 mm and 0.8 mm thick aligners per aligner series and extended the time interval to 2-3 weeks wearing time, respectively.

Maeda et al. reported that they spend twice as long as usual on each treatment step for the correction of migrated teeth in a periodontal compromised dentition using fixed orthodontic appliances and no further bone or attachment loss occurred [30]. In our case, the total treatment time amounted 6 months, in which the right upper central incisor could be successfully aligned and fixed in position with a bonded retainer. The treatment time of 6 months is in the range of treatment for periodontal compromised teeth that have been intruded with fixed orthodontic appliances treated approximately 10 months [31] and, depending on the amount of intrusion, was comparable to our case.

Permanent retention is strongly required in adult periodontal patients due to the imbalance of functional forces [18] and the risk of relapse, and splinting with a fixed retainer

has also been reported to have a positive effect on attachment of connective tissue and bone regeneration [32].

Although, in the literature a reduction of vertical and horizontal dimensions of infrabony defects after orthodontic correction of pathologic tooth movement is frequently reported [12,16,18,33], attachment gain should be considered critical, because most of the studies have been used periapical radiographs which are not precise enough to exactly measure three-dimensional infrabony defects [16,34], and so far there is no histologic evidence in humans that orthodontic intrusion produces new attachment [2]. Likewise in our study and according to reports of Lindhe et al. who noted that orthodontic treatment after periodontal therapy can move teeth without attachment loss, although it does not affect the clinical attachment level itself in a positive way [35], we could not find any improvement of infrabony pockets by clinical as well as radiographic examination, whereas vice versa no aggravation of the infrabony defect could be found. This might be attributed to the regular and proper professional plaque control during our orthodontic treatment [36]. Otherwise, the fact that no attachment gain could be ascertained, may also be due to root resorption that is very likely to occur concomitant with intrusion forces [37]. Thus, as recommended [16,37], in our study, light forces were used for intrusion of the right upper central incisor counting less than 10 g. Absence of root apex resorptions using these forces have been reported earlier and have also been suggested to be safe [16]. In our case study post-orthodontic periapical radiographs did not reveal root apex resorption with reduction in root length compared to baseline, making it unlikely that such side effects had been occurred. Nevertheless, due to orthodontic tooth movement periodontal hard tissue was not fully reorganized at the end of the investigation period. May be in our case however a slight attachment gain could be realized based on improved clinical soft tissue conditions, but could not be measured based on the radiographic images, due to unprecise head repositioning making it impossible to measure such slight distance relevant to our case. The follow up revealed an arrest of the anterior pathologic migration, stable periodontal conditions and a successful aesthetic and functional final result.

Kandasamy et al. evaluated changes in the interdental papillae heights following orthodontic alignment of anterior teeth in young patients aged between 13 and 16 years and could prove that the heights of the interdental papillae increased following palatal movement of labial placed or imbricated incisors and following the intrusion of one incisor relative to an adjacent one, whereas the interdental papillae reduced following labial movement of an imbricated or palatal placed incisor or closure of a diastema, and they suggested that these facts might be even more important in older patients [14]. Concerning these observations, the corrections we performed had been advantageous for the treatment outcome which could be demonstrated by improved clinical results. In the case presented here, pre-orthodontic open gingival embrasure (black triangle) between the maxillary central incisors could be successfully reduced due to intrusion and retraction. After orthodontic realignment, an exposure of the cemento-enamel junction of the right upper central incisor was not visible anymore and the height of the interdental papillae

increased but did not completely fill the interdental space. As it is known, the bone loss caused by periodontal diseases increases the alveolar bone - interproximal contact distance, resulting in an open gingival embrasure [38]; vice-versa intrusion can reduce that distance, at the same time contributing to restore gingival papilla. As a rule, a distance between 5 and 6 mm from the interproximal contact point to the alveolar crest is most critical and determines the presence or absence of an open gingival embrasure [39], and an 1 mm increase in that distance increases the probability of an open gingival embrasure by 78 to 97% [40,41]. Furthermore, short and more incisally positioned interproximal contacts are more likely to be associated with open gingival embrasures [41]. Interproximal enamel reduction and recontouring the mesial surfaces of the central incisors would have been lengthened the contact point and moved it more gingival, thus resulting in an even better gingival papilla [38], but the patient did not approved to that procedure. Nevertheless, the esthetics of the patient could be substantially improved.

The one year post-therapeutic control revealed no further bone loss and the right upper central incisor has since then been asymptomatic and in a good tight position. The patient was very satisfied with the treatment outcome. According to Franke et al. who noted that patients motivation and compliance is the key to success and a good long-term prognosis [8], a stable long-term result has to be expected.

Conclusion

The following can be summarized:

- Aligner treatment is a good treatment option to splint and at the same time correct mobile and periodontal pre-injured teeth.
- With aligner treatment force application, predetermined by the set-up, can be reduced to a minimum.
- Auxiliary elements, in our case buttons and elastics, can be helpful instruments to realize three-dimensional tooth movement (intrusion and alignment).
- By intrusion and retraction, a reduction of black triangle could be achieved, at the same time preserving periodontal conditions.
- The modified aligner appliance combined with light intrusive forces seems to be advantageous in application of axial force directly through the centre of resistance.
- The formation of new connective tissue attachment after orthodontic intrusion could not be proofed by the methods used in our case study, but periapical radiographs revealed no negative impact on periodontal pocket formation and clinical conditions illustrated an improvement of soft tissue after conclusion of the orthodontic treatment.

From the patient's point of view, a huge aesthetic improvement could be reached by the orthodontic treatment, and indicates that minimal invasive aligner therapy in the aesthetical sensitive area is possible even in case of distinctive periodontal injury and massive bone loss, if absolute plaque control is ensured during realignment.

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Conflict of interest statement

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Authors' contribution

All authors have significantly contributed to this work and the development of the paper in the following manner:

Ute Ulrike Botzenhart: analyzed the case; planned and performed the patients' treatment; performed literature research; wrote the manuscript; analyzed, interpreted and discussed the case.

Tomasz Gredes: performed literature research; revised the manuscript for important intellectual content; carried out proof reading.

Tomasz Gedrange: carried out proof reading; gave financial approval for the final version to be published.

All authors read and approved the final manuscript and are in accordance with the manuscript content and its interpretation.

Patient approval

The patients' verbal and written informed consent was obtained concerning the publication of anonymized clinical data, radiographs and images prior to the preparation of the manuscript.

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