DOI: https://doi.org/10.53350/pjmhs20221611868

ORIGINAL ARTICLE

Outcome of Combined Periodontal-Orthodontic Treatment of Pathologic Tooth Migration: A Longitudinal Study

SAHIBZADI FATIMA TARIQ[1], MOHAMMAD AUN ALI MEHDI[2], SHAZMEEN ZAHRA[3], TAIMUR KHAN[4], SAMIR AZEEM[5], HIJAB FARID[6]
[1]*Assistant Professor, Oral Pathology, Rehman College of Dentistry, Peshawar*
[2]*General dentist Rawal institute of health sciences (Rawal Dental college)*
[3]*General Dentist, Islamabad Medical and Dental College, Chakwal*
[4]*Associate professor orthodontics, FMDC Abbottabad*
[5,6]*Assistant professor, Liaquat College of Medicine and Dentistry, Karachi*
Correspondence to: Sahibzadi Fatima Tariq

ABSTRACT

Introduction: A number of periodontal bone abnormalities, most of which are horizontal, have been associated with flared and long incisors. Individuals with anterior incisor displacement and periodontal disease may benefit from orthodontic-periodontal therapy.

Objective: To determine the outcome of combined periodontal-orthodontic treatment of pathologic tooth migration

Study design: A longitudinal study

Place and Duration: This study was conducted at Rehman college of dentistry Peshawar, Pakistan from February 2022 to July 2022

Methodology: A 4-person team designed the study's procedures. On 56 maxillary incisors with horizontal bone anomalies, this surgery was performed to remove circumferential supracrestal fibrotomy and orthodontic-periodontal therapy. To compensate for the angular bone shortage in front teeth treated with orthodontics, guided tissue regeneration and periodontal regenerative surgery were performed. Before, throughout, and six months after guided tissue regeneration treatment (T1), cone-beam computed tomography images were done (T2). At each of the first three time points, the depth of the probing pocket and the degree of clinical attachment loss were determined. Paired t-tests were used to analyse the data.

Results: Clinical attachment loss decreased by 0.28 mm from T0 to T1 ($P < 0.05$). The distance between the cementoenamel junction and the bone top decreased by 0.65 mm ($P < 0.05$). Alveolar bone thickness decreased by 0.45 mm on both the lingual and labial sides of the bone ($P<0.05$). Bone anomalies in some teeth have been converted from horizontal to vertical. From T1 to T2, radiographic testing revealed a 2.16 mm vertical and 1.45 mm horizontal bone redeposition ($P<0.05$), as well as improvements in probing pocket depth and clinical attachment loss ($P<0.05$). During combination therapy, the cementoenamel distance decreased from 2.10 mm to 1.31 mm ($P < 0.05$).

Conclusion: We were able to address periodontal diseases caused by improper bone implantation by combining orthodontic and periodontal treatment. By altering the bone structure, it is possible to improve the outcome of directed tissue regeneration following orthodontic invasion with fibrotomy.

Keywords: orthodontic and periodontal treatment, outcome, bone implantation, Periodontal disease

INTRODUCTION

Periodontitis is a prevalent condition seen in dental clinics. When the supporting tissues that hold the teeth in place are damaged by periodontal disease, teeth can procline, a diastema, rotate, extrude, or drift. [1] Periodontal tissue loss and early occlusion contact are both consequences of anteriorly displaced incisor-induced periodontitis. Individuals with this disease typically require orthodontic treatment. [2]

Periodontal regeneration occurs when new bone and cementum are formed, as well as when newly formed fibers in the cementum and alveolar bone are regenerated. It is possible to restore a healthy and functional dentition with proper orthodontic and periodontal synchronization. [3] Orthodontic tooth movement regularly reshapes the alveolar bone. When a tooth incursion leads to marginal bone resorption as a result of junctional epithelium displacement, it is necessary to resorb the periodontal ligament gap to preserve periodontal width. Circumferential supracrestal fibrotomy therapy for rotated teeth may be useful[4].

Recent research has established that orthodontic intrusion in combination with circumferential supracrestal fibrotomy is a promising therapeutic option for anterior tooth extrusion. [5, 6, 7] There is less bone loss when dental encroachment is corrected with circumferential supracrestal fibrotomy. A cone-shaped fault may emerge as a result of this incursion, causing the horizontal to assume an angle configuration. Patients with periodontitis are more prone to experience bone loss in both the horizontal and vertical directions (angular). One tooth resorbs more angular bone than the other in terms of angular bone loss. The establishment of infrabony pockets on the apical alveolar crest is related to angular bone loss. Horizontal bone loss is the most common kind of alveolar bone resorption. The pocket is deepest between the alveolar crest and the apical ridge. Bone loss can occur at the coronal crest of the alveolar crest, which is also the location of the pocket's lower half.

Orthodontic treatment may or may not result in the development of new attachments.[8, 9] Grafts and regulated tissue regeneration can be used to accomplish this. Periodontal regeneration operations are considered ineffective due to the preponderance of horizontal bone abnormalities in flared and elongated incisors. [10] If orthodontic therapy is successful in reversing a horizontal bone defect, controlled tissue regeneration may aid in the healing of periodontal tissue and long-term stability. [11]

The goal of this study was to assess whether a combination of orthodontic and periodontal treatment was as helpful as anticipated.

METHODOLOGY

The participants in this study ranged in age from 20 to 40 years and were diagnosed with chronic periodontitis (11 females and 3 males). This work was authorized by University's biomedical ethics committee. Before the study could begin, all participants were required to sign a consent form.

Good oral hygiene with baseline (T0) plaque and bleeding scores of less than 15% and 25% for the entire mouth; maxillary anterior teeth migration and extrusion due to periodontal disease; periodontal disease previously treated with scaling and root planning and oral hygiene instructions; abstinence from smoking; obvious bone deformities depicted in radiographs and requirement of orthodontic treatment was the inclusion criteria of the study.

The treatment plans were as follows:

1 As an initial step, periodontal therapy is indicated. The patient had scaling, root planning, and dental hygiene training prior to beginning orthodontic therapy. Dental hygiene and biofilm reduction were incorporated into the patients' comprehensive

periodontal treatment plan (full-mouth plaque score < 15 percent; full-mouth bleeding score, < 25 percent).

2 In the conventional circumferential supracrestal fibrotomy surgery, a surgical blade is placed into the gingival sulcus and the epithelial attachment surrounding the afflicted teeth is severed. The blade cuts through the transeptal fibers when it reaches the periodontal ligament. Throughout the incisor invasive movement, the same periodontist administered all circumferential supracrestal fibrotomy treatments once a month. Additionally, root planning was used to eliminate inflammatory granulation tissue from around the periodontal gap.

3 Braces were used to secure the maxillary incisors and first molars. According to the study, an intrusive mechanism was employed to intrude between the teeth, straighten them, and seal the gap between them following a circumferential supracrestal fibrotomy. Gentle pressures of 10 to 15 g per tooth were used, depending on the residual periodontal support. Following the invasion, a flat and aligned arch was formed by gluing in everything but the incisors and first molars. Throughout this time span, professional prophylaxis was performed on the orthodontic appliance every three months. Active orthodontic treatment was required for an average of 19 months. After the directed tissue regeneration process was completed, the fixed orthodontic equipment remained in place.

Patients with angular bone deficits in their maxillary incisors underwent regeneration surgery. The same periodontist performed periodontal rejuvenation surgery on all of the teeth. At the conclusion of treatment, patients were given a resin-bonded splint to ensure the retention of their anterior teeth.

When the patient had orthodontic therapy at T0 and guided tissue regeneration surgery six months later (T2), CBCT scans were acquired using the same procedure and machine. The exposure conditions employed were 60 kV, 3-5.5 mA (depending on patient size), and a 40-by-30-mm scan volume with a 17-second scan rotation. Only the maxillary incisors were scanned to minimize radiation exposure. Without the scans, healing would have been more difficult. Numerous surgical procedures need the use of guided tissue regeneration. To execute focused tissue regeneration, it is critical to have a thorough understanding of the alveolar bone deficit. CBCT images provide more diagnostic and quantitative information than conventional radiography.

For primary data reconstructions, the Accuitomo workstation's acquisition software (i-Dixel) supplied axial, frontal, and sagittal views. After applying the I-Dixel method, the slice thickness and interval were set to one millimeter for subsequent reconstruction. Once the tooth had been reconstructed, an image plane was aligned with two perpendicular image planes. The teeth's axial, coronal, and sagittal planes were now visible.

The depth of each maxillary incisor's probing pocket and clinical attachment loss at T0 and T1 were determined using the Williams probe (in mm). The probing pocket depths and clinical attachment losses in patients who had guided tissue regeneration surgery were analysed at two-time intervals, T1 and T2. The following criteria were used to assess bone morphology from T0 to T1. The distance between the marginal bone crest and the cementoenamel junction was used to determine marginal bone loss. Coronal and sagittal planes were used to determine the labial and palatal bone levels, whereas sagittal planes were used to determine the mesial and distal bone levels.

The labial, palatal, and total alveolar bone thicknesses were measured apically in the sagittal plane. A study was undertaken to determine whether orthodontic invasion resulted in a deep and narrow bone defect. Two lines were employed to determine the angle: one from the root surface to the bottom of the bone defect, and another from the greatest coronal extension of the interproximal bone crest to the other. Sagittal and coronal planes were employed to examine bone deficiencies in the labial and palatal regions, respectively.

Transient (T1) to permanent (T2) directed tissue regeneration elucidates infrabony defect changes. The distance vertically between the root surface and the alveolar crest's protrusion and horizontally between the bone crest's marginal protrusion and the root surface revealed the most apical location of the bony defect. The distance between the cementoenamel junction and the most apical bone defect point was used to evaluate the location of an infrabony defect. Both the T0 to T1 and T1 to T2 radiographs were analysed twice. Every two weeks, the same individual took all measurements (T.C). The two metrics were averaged and the mean was selected.

Statistical analysis: We compared the values of the parameters prior to and following therapy. To compare two sets of numbers, the t-test was utilised. Statistical significance was defined as a p-value less than 0.05. Radiographic imaging can be used to detect an aberration in bone morphology by calculating the angle of the bone defect.

RESULTS

Between T0 and T1, the form of the alveolar bone, periodontal health, and clinical attachment loss all improved. Despite a 0.28 millimeter reduction in clinical attachment loss, the depth of the probing pocket did not change considerably. On each of the four surfaces, the variances in bone height were 0.77, 0.74, 0.54 and 0.57 mm. This resulted in a statistically significant difference. T0: 4.87 mm; T1: 4.22 mm, a difference in marginal bone loss that is statistically significant. There was a 0.07 mm rise in alveolar bone thickness that was statistically insignificant (As shown in Table 1)

The labial thickness, on the other hand, increased, whilst the palatal thickness dropped. At the conclusion of orthodontic treatment for eight individuals, seventeen angular bone abnormalities were discovered in fourteen teeth. Labial bone flaws varied between 18 and 25 degrees; defects ranged between 15.62 and 26.89 degrees, and flaws in the four mesial bones ranged between 18.17 and 25.12 degrees. 24.81, 39.75, 30.94, 31.76, 20.71, 20.14, and 29.88 degrees were the angles of the distal bone defects. Nine teeth between the ages of T1 and T2 were used in an experiment of guided tissue regeneration surgery. Following therapy with focused tissue regeneration, infrabony deficits have improved. As stated in Table II, clinical attachment loss was reduced by 3.31 millimeters, while probing pocket depth was decreased by 2.88 millimeters. Both of these areas have witnessed statistically significant reductions (P <0.05). According to radiographic examinations, the vertical defect dimension had a bone redeposition of 2.16 ±0.69 mm (P<0.05); the horizontal defect dimension had a bone redeposition of 1.45 ±0.91 mm (P<0.05). Following combination therapy, the apical bone defect-cementoenamel junction gap shrank by 2.12-1.31 mm (P <0.05).

Table 1: Mean at T0, T1 and T1-0

	T0		T1		T1-0			
Measurement (mm)	Mean	SD	Mean	SD	Mean	SD	t	P
Mesial	5.06	1.62	4.29	1.26	0.77	1.15	4.241	<0.001
Distal	5.43	1.71	4.68	1.46	0.74	0.85	5.526	<0.001
Labial	4.63	1.21	4.08	1.36	0.54	0.99	3.253	<0.001
Palatal	4.27	1.86	3.69	1.73	0.59	1.18	2.871	0.006
Mean	4.87	1.66	4.22	1.49	0.67	1.05	7.794	<0.001
Labial bone thickness	2.01	1.09	2.58	1.55	0.55	1.03	3.173	0.003
Palatal bone thickness	5.68	1.66	5.22	1.82	0.47	1.23	2.262	0.032
TLa + TPa	7.73	1.39	7.82	1.54	0.09	0.92	0.542	0.593
Pocket depth	2.76	0.93	2.69	0.81	0.08	0.76	1.03	0.302
Attachment loss	3.38	1.48	3.11	1.17	0.28	0.18	2.86	0.003

Table 2: Clinical attachment loss

T0			T1		T1-0			
Measures	Mean	SD	Mean	SD	Mean	SD	t	P
Pocket depth	5.92	1.06	3.03	1.08	2.88	1.17	16.82	<0.001
Attachment Loss	7.01	1.82	3.84	1.56	3.31	1.58	13.71	<0.001
Cemento enamel junction to bone defect apical point	6.27	0.86	4.18	1.19	2.12	1.31	4.361	<0.005
Alveolar crest Projection to Bone defect Apical point	4.29	0.88	2.13	1.28	2.16	0.69	8.351	<0.001
Marginal bone crest to alveolar projection	3.57	0.64	2.12	0.61	1.45	0.93	4.762	<0.001

DISCUSSION

The purpose of this study was to determine whether a combination of orthodontic and periodontal therapy could aid in the restoration of periodontal tissue. The effects of the combo treatment were evaluated using CBCT images of maxillary alveolar bone morphology[12, 13]. CBCT scans provide more diagnostic and quantitative information in three dimensions about periodontal bone levels than conventional radiography does. When it comes to interproximal zones, CBCT is just as reliable as periodontal probes and radiography. The inherent constraints of two-dimensional radiography have limited its diagnostic value for periapical and periodontal disorders. The objective of this study was to determine the accuracy of CBCT in quantifying dry-skinned osseous periodontal deficiencies. [14]

By assessing bone faults directly using a calliper, we were able to evaluate various methods of bone evaluation. Periapical radiographs detected just 67% of the anomalies, however, CBCT detected 100% of the problems due to its three-dimensional nature. This ex vivo analysis found no statistically significant differences between the three treatment regimens in terms of the parameters analysed. When radiography is unable to detect abnormalities in the buccal and lingual regions, the CBCT approach is recommended.

The purpose of this study is to determine whether a combined orthodontic-periodontal method can be employed to treat migrating incisors. As a result of the investigation, patients' clinical and radiological markers improved dramatically. The absence of a substantial reduction in the mean probing depth between T0 and T1 established periodontal health. After circumferential supracrestal fibrotomy surgery, clinical attachment loss decreased by 0.28 millimeters, indicating improved periodontal health. Indeed, the x-rays were accurate. To gain access to the incisors and to change the horizontal to the angular shape of the bone defect between T0 and T1, we intended to use circumferential supracrestal fibrotomy and orthodontic therapy.

The bone structure of the maxillary alveoli was investigated using CT scanning. Labial and palatal bones, as well as distal and mesial marginal bones, have increased in number. According to the study's findings, marginal bone loss was 0.67 mm less than central bone loss (mean). This metric can be used to determine the efficacy of incisor intrusion and the amount of root absorbed into the bone surrounding the incisor. The growth of the bone surrounding the teeth demonstrates that teeth can be vertically transferred into the bone. [15-17] Further research is necessary to prove the treatment's therapeutic value following orthodontic intrusion with circumferential supracrestal fibrotomy.

Following orthodontic treatment, it was demonstrated that the alveolar bone was totally maintained. On the other hand, the root's crown had been relocated. The thickness of the labial bone increased greatly (0.55 to 1.03 mm), however, the thickness of the palatal bone dropped dramatically, according to this study (0.47 ± 1.23 mm). As a result, the root apex migrated closer to the alveolar ridge's genesis centre. Yodthong et al findings' corroborate this. [18] The alveolar bone crest is convex and pointed in front; it is flat and concave in the rear. Horizontal bone loss occurs almost invariably as a result of incisor resorption during this period. [19]

As a consequence of our examination, we noticed a strange abnormality. Several teeth had developed a horizontal to angular shape as a result of a bone defect. On the periodontal side, only a cone-shaped bony defect was visible due to alveolar bone loss caused by the intrusion. Circumferential supracrestal fibrotomy altered the shape of the bone defect, thereby reducing bone loss following tooth intrusion. According to Shi et al [20], similar effects were observed in a study of 16 individuals with anteriorly misplaced teeth. While circumferential supracrestal fibrotomy was avoided in some instances, orthodontic encroachment was performed. Crestal bone height was increased following circumferential supracrestal fibrotomy orthodontic therapy. Between the fibrotomized and nonfibrotomized groups, statistically, significant differences existed.

Guided tissue regeneration is the most successful regenerative dental technique (GTR). Only guided tissue regeneration is an option for infrabony lesions that are less than two or three walls thick. [21] Utilizing directed tissue regeneration, it is possible to increase the depth and narrowness of a horizontal bone defect in order to stimulate periodontal growth and repair. Due to pretreatment bone loss, an angular bone anomaly was observed in 14 of the teeth in our study. These defects, which have an angle ranging from 15.62 to 39.75 degrees according to this study, require targeted tissue regeneration. Prior to orthodontic treatment, the teeth protruded or there was a large space between them with extreme flaring. As a result, it may be necessary to consider tooth regeneration surgery.

CBCT revealed angular abnormalities in eight of the eight patients who received treatment. Between T1 and T2, there was a fill level difference of 2.16 ±0.69 mm, and between T1 and T2, there was a fill level difference of 1.45 ±0.93 mm between the most apical location of the bone defect and its cementoenamel junction, a distance of between 2.11 and 1.30 mm. The purpose of this study was to use tissue regeneration and orthodontic incursion in conjunction with circumferential supracrestal fibrotomy to realign teeth and reestablish radiographic bone.

According to certain studies, tooth intrusion is associated with an increase in deformity and blood flow. The environment for tissue regeneration technology has improved [22, 23, 24]. Osteoinductive drugs can be used to increase the number of mesenchymal cells, which can then differentiate into bone and periodontal structure-rebuilding cells. Concentrating on problems and their manifestations is critical for a successful regeneration process. Collaboration with other specialists to develop a treatment plan is critical for an orthodontist. It is possible to successfully treat individuals with horizontal bone deficiency by combining orthodontics and periodontal regeneration. Over time, both the alveolar bone height and the periodontal index increased significantly**.**

CONCLUSION

Combining orthodontics and dental care was investigated in this study. It is impossible to overstate the critical nature of a coordinated strategy in treating adult orthodontic patients who have experienced bone loss. When the root was shifted near the tooth's apex, orthodontic intrusion with circumferential supracrestal fibrotomy increased labial bone thickness and improved targeted tissue regeneration. Circumferential supracrestal fibrotomy and orthodontic-guided tissue regeneration may be required if a tooth or teeth have significant spacing between them.

Funding source: None
Conflict: No conflict of interest
Permission: It was taken from the ethical review committee

REFERENCES

1. David Herrera, Mariano Sanz, Moritz Kebschull, Søren Jepsen, Anton Sculean, Tord Berglundh, Panos N (2022). Papapanou, Iain Chapple, Maurizio S. Tonetti, Treatment of stage IV periodontitis: The EFP S3 level clinical practice guideline, Journal of Clinical Periodontology, 10.1111/jcpe.13639, 49, S24, (4-71).
2. Martin, C., Celis, B., Ambrosio, N., Bollain, J., Antonoglou, G. N., & Figuero, E. (2021). Effect of orthodontic therapy in periodontitis and non-periodontitis patients: A systematic review with meta-analysis. Journal of Clinical Periodontology.
3. Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McKenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. British Medical Journal, 372, n160.
4. Aimetti, M., Garbo, D., Ercoli, E., Grigorie, M. M., Citterio, F., & Romano, F. (2020). Long-term prognosis of severely compromised teeth following combined periodontal and orthodontic treatment: A retrospective study. International Journal of Periodontics and Restorative Dentistry, 40, 95– 102.
5. Nibali, L., Koidou, V. P., Nieri, M., Barbato, L., Pagliaro, U., & Cairo, F. (2020). Regenerative surgery versus access flap for the treatment of intra-bony periodontal defects: A systematic review and meta-analysis. Journal of Clinical Periodontology, 47(Suppl 22), 320– 351.
6. Papageorgiou, S. N., Antonoglou, G. N., Michelogiannakis, D., Kakali, L., Eliades, T., & Madianos, P. (2020). Orthodontic treatment of teeth with pathological tooth flaring, drifting, and elongation among periodontitis patients: A systematic review with meta-analysis [dataset]. Zenodo.
7. Papageorgiou, S. N., Koletsi, D., Iliadi, A., Peltomaki, T., & Eliades, T. (2020). Treatment outcome with orthodontic aligners and fixed appliances: A systematic review with meta-analyses. European Journal of Orthodontics, 42, 331– 343.
8. Attia, M. S., Hazzaa, H. H., Al-Aziz, F. A., & Elewa, G. M. (2019). Evaluation of adjunctive use of low-level diode laser biostimulation with combined orthodontic regenerative therapy. Journal of the International Academy of Periodontology, 21, 63– 73.
9. El-Attar, H., El-Kadi, A., Rabie, A., Ezz-el-Arab, A., Salah, N., & Bedair. (2019). Evaluation of the combined orthodontic-periodontal therapy in the management of extruded anterior teeth in patients with aggressive periodontitis. International Journal of Health Sciences and Research, 9, 25– 38.
10. Papageorgiou, S. N., Antonoglou, G. N., Martin, C., & Eliades, T. (2019). Methods, transparency and reporting of clinical trials in orthodontics and periodontics. Journal of Orthodontics, 46, 101– 109.
11. Kumar, N., Jhingta, P., Negi, K. S., Bhardwaj, V. K., Sharma, D., & Thakur, A. S. (2018). Combined Periodontal-Orthodontic Treatment of Pathologic Tooth Migration: A Case Study with 10-Year Follow-Up. Contemporary clinical dentistry, 9(Suppl 2), S377–S381.
12. Chhibber, A., Agarwal, S., Yadav, S., Kuo, C. L., & Upadhyay, M. (2018). Which orthodontic appliance is best for oral hygiene? A randomized clinical trial. American Journal of Orthodontics and Dentofacial Orthopedics, 153, 175– 183.
13. Papageorgiou, S. N., Xavier, G. M., Cobourne, M. T., & Eliades, T. (2018). Effect of orthodontic treatment on the subgingival microbiota: A systematic review and meta-analysis. Orthodontics and Craniofacial Research, 21, 175– 185.
14. Jepsen, S., Caton, J. G., Albandar, J. M., Bissada, N. F., Bouchard, P., Cortellini, P., Demirel, K., de Sanctis, M., Ercoli, C., Fan, J., Geurs, N. C., Hughes, F. J., Jin, L., Kantarci, A., Lalla, E., Madianos, P. N., Matthews, D., McGuire, M. K., Mills, M. P., … Yamazaki, K. (2018). Periodontal manifestations of systemic diseases and developmental and acquired conditions: Consensus report of workgroup 3 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. Journal of Clinical Periodontology, 45(Suppl 20), S219– S229.
15. Papageorgiou, S. N., Papadelli, A. A., & Eliades, T. (2018). Effect of orthodontic treatment on periodontal clinical attachment: A systematic review and meta-analysis. European Journal of Orthodontics, 40, 176– 194.
16. Carrasco-Labra, A., Brignardello-Petersen, R., Santesso, N., Neumann, I., Mustafa, R. A., Mbuagbaw, L., Etxeandia Ikobaltzeta, I., de Stio, C., McCullagh, L. J., Alonso-Coello, P., Meerpohl, J. J., Vandvik, P. O., Brozek, J. L., Akl, E. A., Bossuyt, P., Churchill, R., Glenton, C., Rosenbaum, S., Tugwell, P., … Schünemann, H. J. (2016). Improving GRADE evidence tables part 1: A randomized trial shows improved understanding of content in summary of findings tables with a new format. Journal of Clinical Epidemiology, 74, 7– 18.
17. Papageorgiou, S. N., Koretsi, V., & Jäger, A. (2017). Bias from historical control groups used in orthodontic research: A meta-epidemiological study. European Journal of Orthodontics, 39, 98– 105.
18. Papageorgiou, S. N., Gölz, L., Jäger, A., Eliades, T., & Bourauel, C. (2016). Lingual vs. labial fixed orthodontic appliances: Systematic review and meta-analysis of treatment effects. European Journal of Oral Sciences, 124, 105– 118.
19. Almeida, R. C., Capelli, J., & Teles, R. P. (2015). Levels of gingival crevicular fluid matrix metalloproteinases in periodontally compromised teeth under orthodontic forces. The Angle Orthodontist, 85, 1009– 1014.
20. Han, J.-Y. (2015). A comparative study of combined periodontal and orthodontic treatment with fixed appliances and clear aligners in patients with periodontitis. Journal of Periodontal and Implant Science, 45, 193– 204.
21. Papageorgiou, S. N., Xavier, G. M., & Cobourne, M. T. (2015). Basic study design influences the results of orthodontic clinical investigations. Journal of Clinical Epidemiology, 68, 1512– 1522.
22. Yijia Xie, Qing Zhao, Zhen Tan, Shuliang Yang, (2014) Orthodontic treatment in a periodontal patient with pathologic migration of anterior teeth, American Journal of Orthodontics and Dentofacial Orthopedics, Volume 145, Issue 5, Pages 685-693, ISSN 0889-5406.
23. Kassebaum, N. J., Bernabé, E., Dahiya, M., Bhandari, B., Murray, C. J., & Marcenes, W. (2014). Global burden of severe periodontitis in 1990-2010: A systematic review and meta-regression. Journal of Dental Research, 93, 1045– 1053.
24. M Panwar, B Jayan, VB Mandlik, AK Jha, (2010), Combined Periodontal and Orthodontic Treatment of Pathologic Migration of Anterior Teeth, Medical Journal Armed Forces India, Volume 66, Issue 1, Pages 67-69, ISSN 0377-1237.