World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(REVIEW ARTICLE)

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Relationship between orthodontic tooth movement and periodontal health: A journal review

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World Journal of Advanced Research and Reviews, 2023, 18(02), 248–257

Publication history: Received on 10 March 2023; revised on 19 April 2023; accepted on 22 April 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.18.2.0689

Abstract

The purpose of this journal review is to analyze the relationship between orthodontic tooth movement and periodontal health. During orthodontic treatment, tooth is moved into several movements, tooth is being intruded, extruded or up righted. Orthodontic treatment force induce an inflammatory reaction in the periodontium. This response is needed for orthodontic tooth movement. Orthodontic appliances may compromise oral hygiene conditions, leading to more bacterial formation. The equilibrium of microbial biofilms, immunological, and inflammatory host responses controls the course of periodontal disease. It is currently uncertain whether the periodontal alterations in orthodontic therapy could be reversible once appliances have been removed. Orthodontists need to understand the pre, during, and post treatment of their orthodontic treatment in relationship with patient's periodontal health to prevent potentially permanent damages caused by orthodontic appliances. *Conclusions*: Effective collaboration provides an improved understanding of clinical issues and a better comprehension of the linkages between various disciplines, especially in orthodontics and periodontics. Particularly in patients using fixed appliances and periodontally susceptible individual, dental hygiene guidelines should be carefully observed.

Keywords: Orthodontic treatment; Orthodontic tooth movement; Periodontal health; Periodontium

1. Introduction

Orthodontic treatment provides optimal tooth alignment, a harmonic relationship between the jaw and occlusal surface, may enhance facial attractiveness, mastication, and phonation, and has positive benefits on both oral and overall health. This contributes to a better quality of life [1]. However, compared to alternative surgical or noninvasive methods, There are reports that the risk and complications connected with the treatment are greatly reduced [2].

The most frequent adverse consequences of orthodontic therapy include both local and systemic effects [2]. These include the following: periodontal problems, dental discolorations, decalcification, root resorption, psychiatric issues, gastrointestinal issues, allergic response, infective endocarditis, and chronic fatigue syndrome [1]. According to an investigation by Tripuwabhrut et al, orthodontic force induce an inflammatory reaction in the periodontium [3]. For orthodontic tooth movement, this response is required [4]. It is currently uncertain whether the periodontal alterations in orthodontic therapy could be reversible once appliances have been removed [5]. To prevent possibly irreversible damages from orthodontic appliances, it is necessary to know about the composition and alterations of periodontal during orthodontic therapy [5].

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2. Effect of orthodontic treatment on periodontal health

The main contributor to periodontitis and gingival irritation is bacterial plaque [6]. By changing the physicochemical conditions for bacterial growth, the use of orthodontic appliances inside the mouth causes qualitative and quantitative alterations [7]. Orthodontic appliances may compromise oral hygiene conditions, leading to more bacterial formation [6]. This increases the probability that gingivitis will advance to periodontitis by causing the supragingival plaque to move into subgingival plaque during tooth movement or tipping [8]. The equilibrium of microbial biofilms, immunological, and inflammatory host responses controls the course of periodontal disease [9]. The production of growth factors including tumor growth factor (TGF) and inflammatory cytokines like interleukin 1 (IL-1), interleukin 6 (IL-6), and interleukin 8 (IL-8) by host cells stimulated by periodontal pathogens which modulates the inflammatory response in periodontal tissues. [10] This can be avoided with good dental hygiene and, if necessary, periodontal surgical procedures performed prior to orthodontic therapy [6].

2.1. Soft tissue changes

Some adverse consequences on the soft periodontal tissue could be investigated during orthodontic tooth movement. The soft tissue alterations that occur most frequently are gingival overgrowth, gingival recessions, and gingival invaginations [11]. In orthodontic therapy, gingival overgrowth is a quite frequent condition. Gingival overgrowth causing a pseudo pocket with or without attachment loss is its result [12]. Several studies indicate the cause of gingival overgrowth:

- As an inflammatory response to the accumulation of bacterial plaque, [13]
- Chemical hypersensitivity caused by banding material, [14]
- Mechanical stress that causes gingival overgrowth and an increase in metalloproteinase-9(MMP-9) levels in gingival crevicular fluid.,[15]
- A nickel allergy reaction that was induced by stainless steel from orthodontic appliances,[16]
- Closing the extraction area with a compressive or retractive force [16].

An interproximal tissue linear invagination known as a gingival invagination has a mesial and distal orientation and a probing depth of at least 1mm. According to reports, gingival invaginations frequently occur and may be more common in the lower jaw [17]. When orthodontic treatment was took longer after tooth extraction and space closure took longer than expected, more cases of gingival invagination were reported. For this reason, effective communication between professionals is importantThe degree of diversity in gingival ingrowth can vary greatly, from a minor superficial crease in the gingiva to severe defects with full penetration of the alveolar ridge [17].

Gingival recessions may leads to root sensitivity, unsatisfactory aesthetics result, increase caries rate, tooth abrasion, and difficulties in maintaining oral hygiene [11]. Several studies indicate the cause of gingival recessions in orthodontic treatment:[11]

- Mechanical trauma by toothbrush,
- Several movement of orthodontic treatments,
- The direction of orthodontic forces,
- Periodontal biotype thickness.

It is always recommended to assess each specific case before developing therapeutic strategy. Prior to orthodontic tooth movement, patients with thin biotypes should receive soft tissue grafting to reduce the probability and severity of gingival recessions. Recessions should be treated once they are still minor in order to improve treatment efficacy [11].

2.2. Bones changes

It has been a wide discussion in both orthodontic and periodontal literatures of bone resorption and bone apposition during mechanical force of orthodontic tooth movement. In orthodontic tooth movement, all components of periodontal attachment, such as all supporting soft tissue, the osseous structure, and periodontal ligament follow the tooth's movements [11]. Individu with decreased but healthy periodontal tissues are also affected by this condition [18]. In patients with compromised periodontal health, light orthodontic forces followed by appropriate dental hygiene management may be adequate to achieve proper tooth alignment [18].

3. Effects of orthodontic treatment on periodontium

In orthodontic treatment, dentist must determine the most appropriate method for tooth movement in each particular case [19]. Minor or partial orthodontic treatment with sectional or removable appliances may be possible in some

instances, nevertheless in the majority cases, fixed appliances is preferred in order to control the movement of teeth in three planes [19].

During orthodontic treatment, tooth is moved into several movements, tooth is being intruded, extruded or up righted [6]. As the tooth is moved:

- The relationship between the CEJ and the bone margin remains unaltered,
- The free gingiva follows the tooth 90% of the distance,
- The attached gingiva follows the tooth 80% of the distance,
- While the mucogingival junction is still in the same place,
- No attachment loss.

Alveolar bone, gingiva, and attachment apparatus follow the tooth when the extrusive movement occurs as a result of the force transferred by the gingival and periodontal fibers [6]. To maintain the health of the supra-crestal connective tissue and to preserve of the original height of the crestal alveolar bone, the inflammatory response in the periodontium produced by the force of orthodontic therapy should be controlled [19].

3.1. Orthodontic extrusion

A tooth is translated along its long axis in a coronal direction during extrusion. Orthodontic extrusion is the term used to describe tooth movement that is accelerated by traction. Using the adequate amount of traction forces will produce in a stress distribution over the periodontal ligament leading to marginal apposition of bone at the alveolar crest [20].

In practical practice, orthodontic extrusion is a relatively common treatment. It is an indication in the following cases:

- Impacted maxillary canine
- Permanent teeth that have been traumatically intruded and need to be orthodontically realigned to the occlusal level
- indications for restoration, such as the management of subgingival restorations, the development of implant sites, and tooth fractures at the cervical margin,
- Periodontal problems include reducing pocket depth and managing vertical bony abnormalities [21]. In addition to other therapies, orthodontics is used to treat specific bony defects [6].

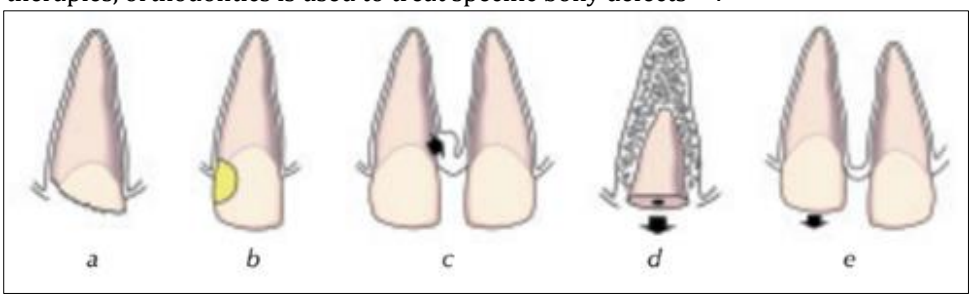

Figure 1 Examples of orthodontic extrusion indications: a) subgingival or infraosseous dental lesion (fracture); b) restoration that abuts on the biological width; c) reduction of localized angular bone defects; d) preimplant extraction; e) trauma or impacted teeth (22).

Two types of orthodontic extrusion:[6]

3.1.1. Slow extrusion with periodontium

The gingiva and bone follow the tooth, therefore removing the bone and performing a gingivectomy are necessary to maintain the aesthetics of the gingiva. It may be referred to as forced eruption and is used to treat isolated bone defects, root fractures, root caries, and procedures to augment the vertical ridge [6].

3.1.2. Rapid extrusion without periodontium

Extruding the tooth and repositioning the margin away from the bone. By performing a circumferential supracrestal fiberotomy, it is possible to prevent the gingiva and bone from following the root. Bone and gingiva will be used to repair biological width violations of restorations when teeth extrude since they do not follow the tooth during this process [6].

Orthodontic extrusion is contraindicated in patients with ankylosis or hypercementosis, vertical root fracture, root proximity and premature closure of embrasures, short roots, and exposure of the furcation [21].

During orthodontic extrusion, the sulcular epthelium first appears as juvenile nonkeratinized tissue (also known as "red patch") before becoming keratinized tissue, increasing the amount of attached gingiva [22]. Several investigations have resulted different recommendations regarding the need for a minor surgical correction after extrusion. When the movement has been achieved, several authors advise doing a single fibrotomy treatment, while others suggest weekly fibrotomy (incision of the supracrestal gingival fibers) [23,24]. Furthermore, a number of clinicians said that after the stabilization period, fibrotomy, gingiva, and/or bone remodeling may still be indicated [25]. In a research investigated by Berglundh T et al,[26,27] repeated fibrotomies were performed on dogs, but they were unable to prevent the gingival attachment's coronal migration. It is still necessary to do in-depth research on human subjects to show the procedure's effectiveness and establish the right frequency [22].

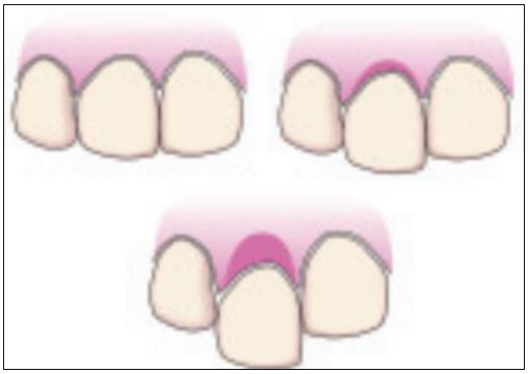

Figure 2 Development of a band of immature nonkeratinized tissue (“red patch”)[22]

3.2. Molar up righting

Non-replacement of missing first molar may lead to mesial tipping of mandibular second molar. Tipping molars can result to multiple of dental health problems, particularly if prosthetic rehabilitation is intended. Zachrisson states that indications of inflammation, angular bone loss, and an apparent pocket at the mesial surface of a tipped mandibular molar are all evidence of periodontal condition that needs to be treated [28].

If the cleaning activity in that area has decreased but no periodontal attachment has been lost, mesial tipping causes in a gingival pocket or pseudo-pocket on the mesial surface. In a while, a pocket that is deeper than 3 mm creates micro ecosystems that encourage the development of infections and resulting loss of attachment [29].

When an inclined molar's mesial surface has a definite osseous defect brought on by periodontitis, uprighting the tooth and its extrusive component pushes the crestal alveolus coronally, reducing the vertical osseous defect. Hence, orthodontic treatment avoids the need to remove unnecessary bone in order to remove pockets and produces adequate space for prosthetic replacement [6].

3.2.1. Molar up righting with furcation involvement

In most cases, molar furcation defects increase or stay unaltered during orthodontic therapy. If tipped molars are involved in the furcation before receiving orthodontic treatment, uprighting while simultaneously extruding with great power may worsen the abnormalities, especially if there is inflammation [6]. If managed in an environment free of inflammation, It is possible to use the light force molar uprighting technique with no further degrading the periodontal furcation [30].

3.3. Orthodontic intrusion

In individuals with excellent dental hygiene, orthodontic intrusion of the maxillary front teeth maintains constant periodontal aspects and could possibly produce a minor clinical attachment gain [31]. Ghezzi examined 14 individuals who received guided tissue regeneration followed by orthodontic intervention in 2008. They found that the stability attained during orthodontic therapy had been preserved. They further supported the concept that the combination of orthodontic and periodontal technique can enhance the patient's aesthetics and stability while preventing damage to the periodontal apparatus by revealing a decrease in probing depth as well as an increase in bone height and papilla [32].

In 2015, Tian Cao et al. reported dental intrusion causes bone loss, and also leading to a widening of the periodontal ligament space at the cervical area and increase the periodontal pockets. They explained this bone loss as the result of the junctional epithelium being displaced, which in periodontal patients caused the marginal ridges to resorb in order to protect the periodontal ligament and increased vertical bone defects. During incisor intrusion, Ghezzi found that the gingiva moves around 60% in the same direction, the epithelium remains attached to the cementoenamel junction, clinical crowns are decreased, and the depth of the gingival sulcus increases by about 40%. This happened not because of swelling or inflammation, but rather because of the accumulation of gingival tissue [32]. Following orthodontic intrusion of the mandibular central incisors, Erkan et al. found that the gingival margin and mucogingival junction moved by 79% and 62% of the actual vertical movement, respectively, in the same direction as the teeth [33].

In 2008, Bellamy et al. done a finding that circumferential supracrestal fiberotomy regulates the reabsorption of marginal bone, which can result in the formation of a cone-shaped bone defect, which can have a number of adverse effects, including increased plaque retention or an increased incidence of tooth decay because mechanical plaque removal is more difficult [34].

A tooth intrusion creates changes in the alveolar tissue. Cementum resorption at the tooth apex and reorientation of periodontal fiber direction were identified as a result of intrusive tooth movement. Alveolar crest remodeling results from the intruding tooth's pressure on supra alveolar fibers. Another study found that when a mandibulary incisor was intruded, the apical periodontal ligament was compressed and alveolar laminal bone and cementum had resorption [40].

There are essentially no areas of tension in the supporting structure during this movement. In contrast to extruded teeth, young patients with intruded teeth only experience minor positional changes as a result of treatment. Since the free gingival fiber bundles only slightly relax, relapse is rather rare. The main fibers are the ones that receive stretch the most. There is a chance that new bone spicules will develop in the marginal area as a result of the invading movement. The stress created by stretched fiber bundles causes these new bone layers to occasionally become slightly bent. The middle part of the roots similarly encounter this strain. The principal fibers rearrange themselves after a few months of retention [35].

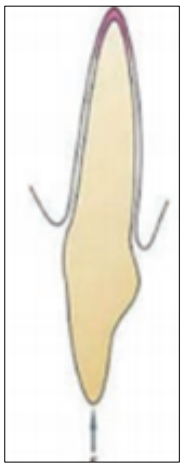

Figure 3 Intrusion of the tooth involves resorption at the bone, particulary around the ape of the tooth [35].

During intrusion, the magnitude of force must be carefully managed. Only light force is necessary since the force is concentrated in a small part near the tooth apex. A light contentious force, as one obtained with the light wire approach, has shown to be advantageous for intrusion in young patients. In some circumstances, the alveolar bone may be closer toward the apex, which raises the risk of apical root resorption. A light interrupted force may be preferable if the bone in the apical area is relatively compact, as it is in some people, to give time for cell proliferation to initiate. Otherwise, direct bone resorption can occur when the arch is reactivated after the rest interval. Pulpal edema and vascularization of the odontoblast are two further pulp tissue alterations that intrusion may bring about [35].

Orthodontic therapy for people with periodontal disease is a problematic issue. While some authors insist that such a strategy is useless and harmful to the periodontium, others suggest that orthodontic therapy reduces the incidence of osseous loss. According to recent study, if the mechanics and oral hygiene are well examined, applying periodontal therapy with orthodontic intervention can improve periodontal health. Light orthodontic pressures are advised in

comparison to a tooth with healthy tissue support because as bone loss advances, periodontal support diminishes and the same force now puts greater stress on the periodontal ligament [36].

3.3.1. Intrusion of anterior teeth in gummy smile

One of the most challenging parts of orthodontic therapy is treating a deep overbite. This adjustment is frequently made by posterior tooth extrusion or a combination of anterior intrusion and posterior extrusion, which is not desired in vertical growers. When there is significant incisal display with protruded incisors, absolute anterior intrusion is necessary [35].

When posterior teeth extrusion using biteplates or cervical headgear do not work, deep bite correction can be done with anterior teeth intrusion. Class II, division 1 malocclusion patients with increased overjet and decreased facial height, as well as a gummy smile and incisor exposure at lip rest (Figure 4), provide excellent candidates for such intervention to enhance esthetics. Since it has been suggested that attractive smiles have limited gingival exposure and that gingival exposure of more than 2 mm provides considerable esthetic improvement, correcting a deep bite with posterior teeth orthodontic eruption does not result in an improvement in appearance [37].

Figure 4 Gummy smile at lip rest.[37]

3.3.2. Intrusion of posterior teeth

Extrusion of the maxillary molars as a result of the loss of opposing teeth leads to occlusal interference and functional issues. (Figure 5). In order to restore proper occlusion, intrusion of the overerupted molars is necessary before multidisciplinary therapeutic dental therapy begin [38].

Figure 5 Intrusion of posterior teeth [38].

The posterior intrusion is one of the most challenging tooth movements in orthodontics because molar has multiple roots. Greater alveolar bone response and a longer treatment time are required for intrusion. It is so difficult to do this movement with conventional orthodontic therapy. Control of three-dimensional movement is crucial in this treatment. The goals of treatment include vertical position, arch form, tooth axes, occlusal plane inclination, and posterior torque. Orthodontic mini-implants improved the treatment process simpler and allowed for the greatest possible preservation of tooth structures [39].

3.4. Tooth movement through cortical bone

According to a widely accepted theory on tooth movement, the bone will follow the path of the migrating tooth. If orthodontic force is applied to move a tooth, the bone around the tooth socket will undergo modifications at the same pace as the tooth, producing a 1:1 ratio of bone remodeling to tooth movement. Vardimon assessed the incisors'

retraction ratio in relation to torque and tipping movements. It was found that a 1:1 ratio would not be produced by either torque movement or tipping. The central incisors' apex moved 3 mm posteriorly, and A point would retract 1.5 mm due to the tipping movement ratio of 1:2. The central incisors' apex moved 5 mm posteriorly, and A point would retrace 2 mm according to the torque movement ratio of 1:2.35. It is believed that the risk of the apex of the central incisors sliding too close to the labial cortical plate is diminished by the mechanical component present in retraction and tipping movement. To determine whether the maxillary central incisors will move in a point A-P or P-A direction, it is suggested to use the ratio 1:2 [40].

Alveolar bone dehiscence and gingival tissue loss occur when teeth are moved out of the alveolar housing or located more facially during orthodontic tooth movement. When the soft tissue apical to the CEJ becomes displaced, it causes gingival recession, which exposes the root surface. When teeth are pushed out of the alveolar housing or positioned more facially, then placed back into the alveolar housing or lingually (original position), complete regeneration of the alveolar bone proceeds with intact junctional epithelium and normal gingival position. Indeed, the soft tissue around a bone dehiscence brought on by orthodontic treatment may include soft tissue elements (vital osteogenic cells) capable of generating bone when the tooth is moved into the alveolar process [6].

3.5. Tooth movement with infrabony defects

According to three studies, if excellent oral hygiene is maintained, orthodontic forces and tooth movement in dentitions with reduced periodontium do not harm the periodontal tissues, But when plaque-induced inflammation is present, similar factors might cause the periodontal tissue to degrade more quickly. In patients with insufficient periodontal support, it is believed that the use of light, sustained orthodontic forces and the absence of gingival inflammation are necessary for achieving excellent treatment outcomes [41].

An experimental investigation on teeth with infrabony pockets discovered that there is no adverse concequences on the attachment level if subgingival infection is entirely eliminated prior to orthodontic movement. In this trial, the angular bone defects were corrected, but no attachment gain was made. In patients with severe periodontal disease, Corrente G et al looked at the possibility of executing orthodontic therapy into migrated incisor infrabony defects. The realignment of the treated incisors (Figure 6) with radiological bone fill, a reduction of the bone defects in horizontal and vertical radiological dimensions (Figure 7), clinical attachment level (CAL) gain, and probing depth (PD) reduction were the outcomes of the combined treatment, which included open flap surgery and orthodontic intrusion. A natural barrier is created when the periodontal ligament fibers are stretched, which slows the downgrowth of epithelial cells. Orthodontic stimulation enhances periodontal ligament cell turnover and increases the possibility that they will repopulate the root surface [42].

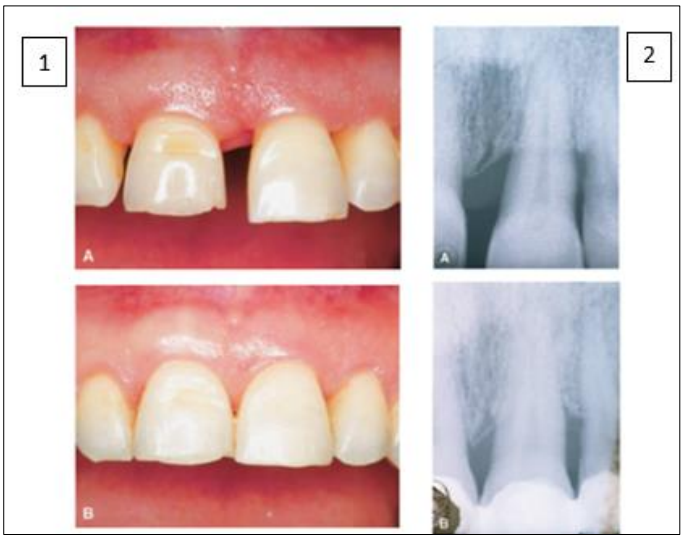

Figure 6 1.Clinical documentation. A) Before therapy. B) After orthodontic therapy. 2. Radiographic documentation. A) Bone defect at baseline examination. B) Bone modifications following periodontal surgery and intrusive orthodontic therapy [42].

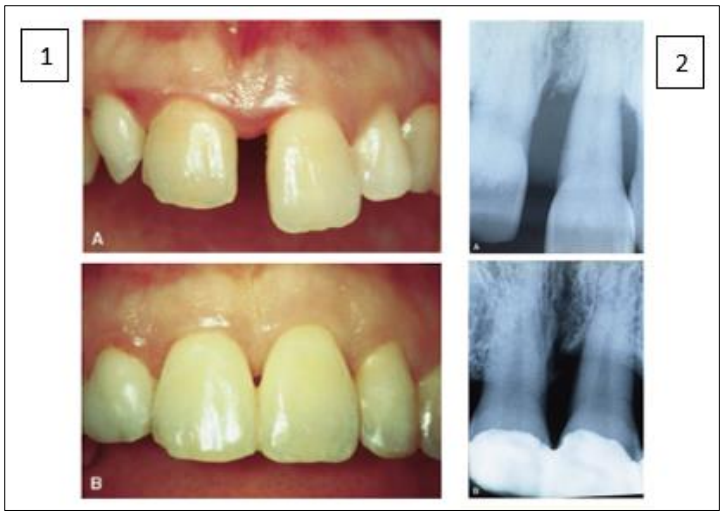

Figure 7 1) Clinical documentation. A) Before therapyt. B) After orthodontic therapy. 2) Radiographic documentation of patient Y. A) Bone defect at baseline examination. B) Bone modifications following periodontal surgery and intrusive orthodontic therapy [42].

3.6. Tooth movement into edentulous areas

Patients with partially edentulous dentitions due to congenitally absent or extraction teeth might gain benefit from orthodontic therapy in achieving better aesthetic and functional outcomes. There is frequently a decreased alveolar bone height. Histological sections on the pressure side of the moving tooth revealed that the supporting bone was considerably thinner than the original bone, indicating that a thin bone plate needed to be repaired. As a result, it is possible to shift a tooth into a bone-height-reduced location using orthodontics while maintaining the height of the connective tissue attachment level and alveolar bone support [6].

3.7. Orthodontic implant side development

According to a study by Amato et al, orthodontic implant site development (OISD) is a therapeutic option for these hopeless teeth that can help the hard and soft tissues around them healing. It showed a 70% bone regeneration efficiency and a 60% gingival augmentation efficiency. There was no restriction due to the tooth's residual attachment level. OISD may be a helpful therapeutic option for regenerating tissues for implant site development in people who necessary conventional orthodontic treatment [43].

4. Conclusion

Aesthetics, functionality, and long-term prognosis are all addressed in coordinated multidisciplinary dental therapy for patients. Effective collaboration provides an improved understanding of clinical issues and a better comprehension of the linkages between various disciplines. For each kind of dental therapy, periodontal health is crucial. Before, during, and after orthodontic tooth movement, a thorough periodontal health assessment should be given to prevent negative effects. Particularly in patients using fixed appliances and periodontally susceptible individual, dental hygiene guidelines should be carefully observed.

Compliance with ethical standards

Acknowledgments

This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Disclosure of conflict of interest

The authors have no conflict of interest to declare.

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