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RELAPSE AFTER ORTHODONTIC TREATMENT

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ABSTRACT

Orthodontic treatment results are prone to relapse over time, which is the unfavorable change in position of teeth to its original position before orthodontic treatment. With that said, retention is an important part of almost every case of orthodontic treatment. There are many contributing factors to the incidence of a relapse. This article aims to explain the incidence and prevention of relapse after orthodontic treatment through reviewing literature published during 2012 to 2022 which discusses topics that are appropriate and related to relapse and retention. Sources were taken from textbooks, journals and websites that can be accessed through Google Scholar and PubMed databases. A total of 30 references were found, and 9 articles were included in the integrative review after further analysis. This article concludes that relapse is a common occurrence after orthodontic treatment because of gingival and periodontal factors, occlusal factors, soft tissue factors, hard tissue factors, and growth factors, and its prevention requires the use of retainers, either removable or fixed, depending on the case.

INTRODUCTION

The relapse after orthodontic treatment has been defined by British Standards Institute as the return of corrected teeth to their original position before treatment. However, a more patient-relevant definition of relapse refers to any change in the final position of the teeth at the end of treatment. Post-treatment tooth movement may involve the teeth returning to their pre-treatment position or shifting in any direction due to dentofacial growth that is unrelated to orthodontic treatment (Littlewood & Mitchell, 2019). Both relapse and tooth movement during orthodontic treatment occur through the same biological mechanisms, which involve increased osteoclast activity and apoptosis on the side of the tooth that is moving, as well as alveolar bone growth (Maziya Yusuf et al., 2023)

Relapse can occur as a result of forces generated by interdental fibers and

dentogingival fibers within the periodontal tissue. These tissues function to keep the teeth in place, so when there is tooth movement, the fibers tend to pull the teeth back to their pre-treatment position. Additionally, relapse can also occur if there is deflection in occlusal contact due to suboptimal final occlusion (Johnston & Littlewood, 2015).

Stability and relapse after orthodontic treatment are unpredictable. Relapse can occur rapidly on day 1 to day 24 after removal of the orthodontic appliance. The loss of pressure when the orthodontic appliance is removed will cause the teeth to start moving back to their original position (Prakosa & Utari, 2016).

The high rate of relapse is largely due to the difficulty in identifying which patients will have stable tooth positions (not requiring retention) and which will have unstable tooth positions (requiring retention), as well as the extent of potential tooth movement after treatment on an individual basis. As a result, all patients are considered to have the potential for relapse, and post-orthodontic retention is recommended to control the factors that drive relapse (Littlewood & Mitchell, 2019).

Retention is the process carried out on an individual after the active phase of treatment, with the aim of keeping the teeth in their new position. This is because the tissues in the oral cavity need time to adapt and maintain their strength and position after undergoing changes (Luther & Nelson-Moon, 2013). The issue of "retention and relapse" is a complex concept because it involves etiological factors, and not all tissues react similarly at the same time. Therefore, the operator must carefully consider all potential related concepts. Retention is regarded as a crucial aspect of orthodontic treatment to maintain the stability of the treatment outcomes (Srivastava et al., 2020).

The implementation of the retention phase should begin with an accurate and logical diagnosis based on parameters such as growth, development, craniofacial clinical conditions, duration of use, ideal function, and pre-treatment conditions, as well as etiology. The goal is to achieve a stable, healthy, functional, and aesthetic occlusion that will last throughout the patient's lifetime. Therefore, the duration of retention use and the type of retention employed may vary for each individual. Common discomforts experienced by individuals using retainers include difficulty swallowing liquids, difficulty speaking, irritation of the soft tissues, particularly the tongue, and excessive saliva (Srivastava et al., 2020).

A long-term study on post-treatment tooth movement with fixed appliances stated that 10 years after the retainer was discontinued, 70% of patients required repeat orthodontic treatment due to worsening post-treatment tooth position over the following decades (Srivastava et al., 2020). Therefore, this review aims to evaluate the presence, causes and prevention of relapse after orthodontic treatment.

METHOD

This writing was based on references obtained from textbooks, journals and websites that can be accessed through Google Scholar and PubMed databases. The references referred to were selected based on inclusion criteria and analysis of relevant references, research, descriptives, and also literature studies from 2012 to 2022 published in English and Indonesian, and discusses topics that are appropriate and related to the literature review. Any literature found meeting the exclusion criteria was eliminated. The exclusion criteria includes literature that were published before 2012 and data that did not have any relevance with the occurrence of relapse after orthodontic treatment.

RESULT AND DISCUSSION

A total of 30 references were found. Based on the inclusion and exclusion criteria, there were 15 articles selected and 15 articles excluded. After going through the analysis process, 9 articles were included in the

integrative review and 6 articles were excluded (Table 1).

Table 1. List of references and summary.

Reference	Aim	Method	Sample	Results
Prakoso *et al.* *(*2020)	To determine the prevalence of relapse after treatment with fixed orthodontic appliances using the Index of Orthodontic Treatment Need (IOTN).	Assessment using the IOTN and descriptive data analysis with the Kolmogorov-Smirnov test and the Wilcoxon test.	n= 24	There was a significant difference in scores after the removal of fixed orthodontic appliances compared to the current scores, indicating a prevalence of relapse after treatment with fixed orthodontic appliances.
Abdulraheem *et al.* (2020)	To identify the movement of lower incisors after orthodontic treatment due to relapse or natural growth.	Measurement of the Little Irregularity Index (LII), inter-canine distance, available anterior mandibular space, number of crowded incisors, and the Tooth Displacement Index (TDI) with study models before orthodontic treatment (T0), immediately after orthodontic treatment (T1), 6 years after treatment (T2), and 12 years after treatment (T3).	n= 90	LII decreased during orthodontic treatment and increased again after the removal of the retainer (T1–T3). Approximately 25% of tooth movements at T2 and T3 did not occur before treatment (at T0), indicating changes due to natural growth rather than relapse from orthodontic treatment.
Al-hamdany AK (2012)	To evaluate changes in dental parameters after treatment measured on study models in patients with different Angle's malocclusion classes.	Average changes in measurements from pre-treatment to post-treatment were calculated and tested with a Paired t-test.	n=113	Class I crowding; changes were minimal and statistically insignificant for most variables. Class I with spacing; showed a tendency for relapse for most observed variables. Class II D1 crowding, Class II with spacing, Class II D1 without crowding or spacing, Class II D1 crowding, and Class III; some variables showed significant changes, with no significant differences for other variables.
Cotrin *et al.* (2022)	To evaluate the effect of third molars on relapse of anterior mandibular crowding in orthodontic patients.	Anterior mandibular crowding was measured using the Little Irregularity Index. Subject models were evaluated three times: before treatment, after treatment, and after retention.	n= 108	No significant statistical difference in anterior mandibular crowding relapse between groups with and without third molars at the post-retention stage.
Scott *et al.* (2020)	To evaluate the impact of gingival thickness and anatomical	The percentage of relapse in patients with gingival cleft and thick anatomical gingiva was compared with patients without	n= 18	Subjects with thicker gingiva had a higher risk of relapse (45%) compared to those with thinner gingiva (43.86%), and patients with space closure gaps had a higher risk of

	variation on relapse occurrence.	gingival cleft and thin gingiva structure at 61 observed sites.		relapse (42.86%) compared to those without gingival gaps and thin gingiva (36.84%).
Naraghi *et al.* (2021)	To evaluate the importance of post-orthodontic retention in impacted upper canines.	Contact point discrepancy (CPD) and Little's Index (LI) were measured on 3D digital study models 1 year after treatment.	n= 63	The average irregularity change was 0.4 mm in the retention group and 1.3 mm in the non-retention group ($P < 0.001$). The maximum change was 2.5 mm in the retention group and 3.2 mm in the non-retention group ($P < 0.001$). Most changes in the non-retention group occurred during the 10-week interim period. Differences between the retention and non-retention groups were statistically significant but not clinically significant.
Ishakoglu S *et al.* (2022)	To examine relapse with a thermoplastic retainer equipped with a microsensor 1 year after treatment.	Little's Irregularity Index (LII), intercanine width, intermolar width, arch length, overjet, and overbite were measured for two groups with short wear time (SWT) and long wear time (LWT) using digital models created before treatment (T0), at debonding (T1), and 6 months (T2) and 12 months (T3) after debonding with thermoplastic retainers equipped with TheraMon microsensors.	n= 42	Irregularity and overjet increased, while transversal measurements and arch length decreased over time in both groups. During retention, overbite decreased in the SWT group but increased in the LWT group. There was a significant difference between groups only for mandibular irregularity. The LII value in the SWT group was significantly higher than in the LWT group for T1–T2 and T1–T3 intervals ($P < 0.05$).
Wiedel-Bondemark (2015)	To compare and evaluate the stability of anterior crossbite correction in mixed dentition with fixed or removable appliances.	Crossbite correction, overjet, overbite, and arch length were measured on study casts before treatment (T0), at the end of the retention period (T1), and 2 years post-retention (T2).	n= 64	At T1, anterior crossbite was corrected in all patients in the fixed appliance group and all but one in the removable appliance group. At T2, almost all treatment outcomes remained stable and similar in both groups. From T0 to T1, only minor differences were observed between fixed and removable appliance groups regarding changes in overjet, overbite, and arch length measurements. These changes had no clinical implications and remained unchanged at T2.
Sonesson *et al.* (2022)	To evaluate and compare bonded retainers on 4 upper incisors, bonded retainers on 4 upper incisors and canines, and vacuum-formed retainers (VFR) for the upper arch.	Little's Index and contact point discrepancy (CPD) were measured on 3D digital study casts. Analysis was conducted 2 years post-retention.	n= 90	All three retention methods showed good capacity for maintaining upper anterior teeth. There were no statistically significant differences in anterior dental irregularity among the three groups.

Etiology of Relapse

Identifying the exact causes of tooth movement after orthodontic treatment is challenging. However, four factors have been proposed as potential reasons for relapse: gingival and periodontal factors, occlusal factors, soft tissue factors, hard tissue factors, and growth factors (Littlewood & Mitchell, 2019).

1. Gingival and Periodontal Factors

Periodontal tissue functions to maintain the teeth in their normal position. Therefore, when there is movement, the collagen fibers in the periodontal tissue tend to pull the teeth back to their original position. To prevent this from happening, the periodontal tissue must be given time to adjust to the new position of the teeth (Littlewood & Mitchell, 2019).

The mechanism of tooth movement through orthodontic treatment occurs when the pressure from the orthodontic appliance acts on the tooth crown and is transmitted through the tooth root to the alveolar bone and periodontal ligament (Wirapradina et al., 2024). The alveolar bone surface that receives pressure undergoes resorption, while the opposite side undergoes tension or apposition to maintain stability according to the physiological movement of the tooth, causing tooth movement. This process is known as remodeling (Littlewood & Mitchell, 2019) (Sumarno et al., n.d.).

Alveolar bone remodeling is crucial because it is the process of maintaining the balance of the tooth-supporting tissue (Pakpahan et al., 2024b) (Pakpahan et al., 2024a). As the tooth moves, the transseptal and supracrestal fibers stretch to follow the new tooth position. However, these tissues may shorten, leading to relapse. Alveolar bone remodeling is completed within one month, periodontal fiber remodeling within 3-4 months, and gingival collagen fiber remodeling within 4-6 months. However, elastic fibers in the dentogingival and interdental areas complete remodeling after eight months (232 days). Tooth movement without surrounding tissue remodeling increases the likelihood of the teeth returning to their original position (Littlewood & Mitchell, 2019).

2. Hard Tissue Factors

Teeth that have recently been moved are surrounded by slightly calcified osteoid bone, making them less stable and more prone to return to their original position. Normally, trabecular bone is oriented perpendicular to the tooth axis, but during orthodontic treatment, it becomes parallel to the direction of pressure. During the retention phase, these teeth may return to their original position (Littlewood & Mitchell, 2019).

3. Occlusal Factors

The way teeth occlude at the end of treatment can affect the stability of their position. If the teeth occlude well at the end of treatment, the orthodontic results will be more stable. When the upper or lower teeth are larger than one another, the oral cavity compensates for the condition. For example, larger upper anterior teeth may cause a deep overbite, while larger lower teeth may lead to an edge-to-edge incisor relationship. Although this information is theoretically acceptable, it has not been clinically proven (Littlewood & Mitchell, 2019).

4. Soft Tissue Factors

Teeth are located in the balance between the tongue on the lingual side and the cheeks and lips on the buccal and labial aspects, known as the neutral zone. Although the tongue muscles are stronger, a healthy periodontium will resist tooth proclination. However, if the teeth move out of this stability zone, they will become increasingly unstable, especially in the lower labial segment. Excessive proclination or retroclination of the teeth can lead to relapse, as the supporting tissues remain active, with bone resorption in the sockets and supporting tissues under pressure. Additionally, if the arch form changes drastically, relapse may occur due to tissue pressure. Therefore, it is advisable to

maintain the lower arch form throughout treatment and adjust the upper arch form accordingly (Littlewood & Mitchell, 2019).

5. Failure to Eliminate Underlying Cause

The cause of malocclusion should be identified during diagnosis, and the treatment phase should be planned to eliminate or reduce the severity of the malocclusion to prevent relapse. For example, failure to stop the thumb-sucking habit, which causes tooth protrusion, can lead to relapse (Littlewood & Mitchell, 2019).

6. Growth Factors

Although most growth in patients is completed by the end of puberty, small changes may occur over time, increasing the risk of tooth relapse. These changes can contribute to relapse. The third molars are the last to appear during tooth development. In many cases, the third molars erupt around 18 to 21 years of age. By this age, most patients have typically completed their orthodontic treatment. The pressure caused by the eruption of the third molars is considered a factor in the irregularity of the anterior tooth alignment, making them prone to relapse (Littlewood & Mitchell, 2019).

Dental relapse also occur because of inappropriate diagnosis and treatment, incomplete treatment, inappropriate retention devices, patient who are not cooperative in using retention devices, failing to eliminate etiological factors of malocclusion, and failing to anticipate new forces that occur caused by changes in the arrangement of the new teeth. Therefore, after orthodontic is completed, the results of the treatment need to be maintained so that they do not return to their original position by using retention devices (Revi et al., 2023).

Relapse Tendency after Orthodontic Treatment

According to Areal & Gandia (2013), the tendency for relapse is greater and occurs more frequently in the lower jaw compared to the upper jaw during the first ten years post-treatment (López-Areal & Gandía, 2013). A significant portion of cases involving crowding or lower incisor crowding that develops in late adolescence is due to delayed mandibular growth in a normal growth pattern. Especially when the lower incisors were previously irregular, even minimal mandibular growth occurring between the ages of 16 and 20 can lead to a relapse to the original position (Gill & Naini, 2011).

The increase in lower incisor irregularity is a common phenomenon after orthodontic treatment. Several studies have confirmed that the likelihood of lower incisor irregularity typically increases during the second, third, and fourth decades of life in untreated subjects, as well as those who have previously undergone orthodontic treatment. The most significant changes in untreated occlusion occur before the age of 18, with most changes happening in the mid-third decade of life. This period coincides with the age range during which most orthodontic treatments are carried out, further complicating retention planning (López-Areal & Gandía, 2013).

Supracrestal periodontal fibers take the longest time to realign. Additionally, the neuromuscular system also requires adaptation to the new tooth positions. Therefore, extended retention for corrected teeth can help in reducing the risk of relapse (López-Areal & Gandía, 2013).

Retention

Retention is the process of maintaining teeth in their ideal aesthetic and functional positions using various mechanical appliances. It is designed to prevent teeth from moving back toward their original malocclusion positions while allowing them to move freely in all other directions. Post-treatment relapse prevention typically involves the use of retainers. According to Naraghi S et al. (2020), patients who do not use retainers experience greater changes after orthodontic treatment compared to those who

do use retainers (López-Areal & Gandía, 2013).

Types of Retainers

Retainers are divided into two types based on their usage: removable retainers, which can be taken off and put on by the patient, and fixed retainers (Shroff, 2016).

Removable Retainers

Removable retainers are those that patients can take off and put back on themselves. These retainers are generally worn part-time, usually at night, except in patients with a high risk of relapse (Gill & Naini, 2011). Removable retainers have several advantages, such as being safer for patients with periodontal tissue issues compared to fixed retainers, easy to clean, usable part-time, and their effectiveness depends on the patient's level of cooperation (Littlewood & Mitchell, 2019). However, their disadvantages include speech impairment at the beginning of use, and unsatisfactory aesthetics (Kusparmanto et al., 2024). Besides, there are potential for damage which can affect the stability of the teeth and the prognosis of treatment relies on patient compliance. If the patient does not follow the guidelines for retainer use, the risk of relapse increases (Littlewood & Mitchell, 2019). There are several types of removable retainers, including:

1. Hawley Retainer

The Hawley retainer consists of an acrylic baseplate, a labial bow with an adjustment loop extending from canine to canine, and retentive components such as Adam's clasps on the first permanent molars (Cotrin et al., 2020). The Hawley retainer provides good retention, prevents anterior teeth from rotating, and closes gaps in extraction spaces (Proffit & Fields, 2019). It can close small gaps in the anterior segment and control overbite (Singh, 2015).

2. Wraparound (Clip) Retainer

The second most commonly used removable retainer is the wraparound or clip retainer, which consists of a plastic bar reinforced by wire along the labial and lingual surfaces of the teeth. In the lower jaw, a clip-on retainer from canine to canine is often used, while in the upper jaw, an anterior clip-on retainer can be useful for adults with long clinical crowns (Proffit & Fields, 2019).

3. Clear (Vacuum-formed) Retainer

This retainer is made from a clear plastic material that is softened and then vacuum-formed over the teeth. The material is transparent and thin, making the clear retainer almost invisible, which most patients prefer due to aesthetic reasons. It is economical, less likely to break, easy to make, and does not interfere with speech. The clear retainer is usually worn only at night. It is most commonly used for the upper jaw and is equally effective in maintaining the alignment of the incisors as bonded-wire retainers (Proffit & Fields, 2019).

4. Begg Retainer

The Begg retainer features a labial arch that extends around the distal aspect of the molar to maintain post-diastema closure. It allows for occlusal settling because no wires cross the occlusal surface. This retainer is less retentive than the Hawley retainer, and the labial bow is more prone to distortion (English et al., 2015).

5. Barrer Retainer

The Barrer retainer is an active retainer used to correct minor irregularities in the alignment of the incisors. Active retainers are those that actively maintain the relationship between the arches during post-treatment growth or actively correct minor irregularities in tooth position (Premkumar, 2015). When placed in the mouth, active force is applied to the teeth until the desired movement is completed. The device can be worn during sleep to minimize changes in maxillomandibular relationships that may occur due to disharmonious growth, encourage differential eruption, and prevent tooth movement as a compensation for

skeletal changes resulting from post-treatment growth (Gill & Naini, 2011).

6. Positioners

Positioners are active devices made from elastomeric materials and are used in cases where occlusion is not optimal at the end of treatment (Littlewood & Mitchell, 2019).

Fixed Retainers

A fixed orthodontic appliance is an appliance attached to the teeth by the dentist and cannot be removed by the patient until treatment is completed. Fixed retainers are typically indicated for maintaining the position of lower incisors during mandibular growth, closing diastemas, preserving space for bridges, patients with periodontal issues prone to tooth migration, in cases of severe rotation, post-correction of palatal canines, and severe overbites (Premkumar, 2015). Fixed retainers are usually bonded to the palatal surfaces of the teeth using composite material (Gill & Naini, 2011).

There are several types of bonded retainers, including multi strand stainless steel retainers bonded to all teeth, rigid retainers, and canine-to-canine retainers. Palatal bonded retainers are less commonly used than lingual bonded retainers because they are more prone to damage from occlusal contact. Labial bonded retainers are indicated for patients who remove orthodontic appliances earlier than recommended, before the eruption of third molars, or as an adjunct to vacuum-formed retainers after the correction of severe canine and incisor rotation with a high risk of relapse (Gill & Naini, 2011).

The advantages of fixed retainers include the fact that they do not need to be removed and reinserted, are aesthetic, and do not cause tissue irritation in the pad area as with removable Hawley retainers. However, the drawbacks include a more complicated and time-consuming installation process, difficulty in cleaning the teeth, and susceptibility to damage (Premkumar, 2015). An example of a fixed retainer is the lingual bar, which consists of a wire attached to the canines and resting on the lingual surface of the lower incisors, just above the cingulum (Proffit & Fields, 2019).

Bonded retainers offer the benefit of being immediately usable, but they can lead to the accumulation of debris and are prone to cracking and discoloration. Patients with fixed retainers must be educated that any residual active force in the wire can cause unwanted tooth movement. Although the long-term use of bonded retainers does not pose significant long-term dental health risks, patients must maintain meticulous oral hygiene around the retainer (Gill & Naini, 2011).

Duration of Orthodontic Retention

Retention is necessary for all patients who undergo fixed orthodontic treatment. Ideally, the use of retainers should be implemented as follows: (Proffit & Fields, 2019).

a. Everyday Use for the First 3 to 4 Months.
   During the first 3-4 months (initial phase), retainers should be worn consistently everyday. For removable retainers, they should only be removed during meals. Fixed retainers should be flexible enough to allow for individual tooth movement during chewing (Proffit & Fields, 2019).
b. Part-Time Use for 12 Months.
   After the initial full-time use, retainers should be worn part-time (typically at night) for the next 12 months. This phase helps to solidify the new tooth positions as the tissues stabilize (Proffit & Fields, 2019).
c. Continuation during Growth Periods.
   If the patient is still growing, part-time use of retainers should continue until the growth period is complete. This is important to accommodate any changes that might occur as the jaws

and surrounding structures develop (Proffit & Fields, 2019).

For practical purposes and to prevent relapse, nearly all patients who have undergone early permanent dentition treatment will need to retain their incisors at least until the end of adolescence. Additionally, in cases of skeletal disproportion, part-time retainer use is recommended (Proffit & Fields, 2019).

The study by Prakosa et al. (2020) was conducted to measure the prevalence of relapse after fixed orthodontic treatment. This study was carried out on 24 samples and involved two components: the Aesthetic Component (AC) and the Dental Health Component (DHC). The AC component assessed the appearance of the teeth from a subjective perspective, focusing solely on the aesthetics (without considering the posterior part). AC measurements were performed by comparing the frontal view of the centric occlusion from the mold taken after removing the fixed orthodontic appliance with the current mold, without comparing the side or occlusal views. On the other hand, the DHC component assessed the condition of the teeth objectively by performing examinations and measurements (Prakosa & Utari, 2016). Results for DHC and AC data were found as followed:

a. DHC results
    i. Right after treatment: 17 subjects (70.84%) did not require treatment, 2 subjects (8.33%) required treatment, and 5 subjects (20.83%) required significant treatment (Prakosa & Utari, 2016).
    ii. Current condition: 14 subjects (58.34%) do not require treatment, 2 subjects (8.33%) require treatment, and 8 subjects (33.33%) require significant treatment (Prakosa & Utari, 2016).
b. AC results
    i. Right after treatment: 24 subjects (100%) did not require treatment, none (0%) required treatment, and none (0%) required significant treatment (Prakosa & Utari, 2016).
    ii. Current condition: 24 subjects (100%) still do not require treatment, none (0%) require treatment, and none (0%) require significant treatment (Prakosa & Utari, 2016).

In the AC component, although there were changes in scores, the treatment need remained unchanged, which indicates no need for treatment. This occurs because the AC component only evaluates the anterior aesthetic aspects without involving the posterior part. This shows a decrease in the number of samples in the "no treatment needed" category and an increase in the number of samples in the "significant treatment needed" category. These results indicate that relapse occurred in the samples, leading to an increased need for treatment. This relapse is evidenced by the worsening severity of malocclusion from the time after the fixed orthodontic appliance was removed until the present. It is difficult to identify the main factors causing relapse, as the causes are multifactorial (Prakosa & Utari, 2016).

The study by S. Abdulraheem (2020) explores changes in teeth after orthodontic treatment by identifying movements of the incisors caused by relapse or natural growth. This research used four study models, which are T0 (before orthodontic treatment), T1 (immediately after orthodontic treatment), T2 (6 years after orthodontic treatment), and T3 (12 years after orthodontic treatment). Linear measurements were conducted, including Little Irregularity Index (LII), inter-canine distance, available anterior space in the lower jaw, number of crowded incisors, and Tooth

Displacement Index (Abdulraheem et al., 2020).

Main findings of this research was that there was a decrease in Little Irregularity Index (LII) results during orthodontic treatment (T0-T1) and an increase after removal of the retainer (T1-T3). Inter-canine distance and Available Anterior Space in the Lower Jaw findings showed similar results, decreasing during treatment and increasing after retainer removal. Tooth Displacement Index results showed that the number of crowded teeth in the anterior lower jaw decreased from T0 to T1 (during treatment) and then increased again (Abdulraheem et al., 2020).

There were no significant differences between T0 and T3, and no significant differences among the three groups. At the final recording, 12 years after treatment (T3), there were 206 teeth that had shifted, rotated, or experienced a combination of both. Of these 206 teeth, 53 teeth (25%) did not show movement or rotation before treatment (at T0), indicating that changes in these teeth were due to natural growth (Abdulraheem et al., 2020).

The study by Al-Hamdany AK (2012) aimed to evaluate post-orthodontic changes in patients with different Angle classifications. Measurements were taken from 113 patients using models to assess labial (AB), buccal (BC), vertical canine (A-BB), vertical molar (A-CC), diagonal arch length (AC), inter-canine width (BB), inter-molar width (CC and DD), and overbite overjet. The results showed that Class I crowding and Class II D1 without crowding or spacing were relatively stable after treatment. However, Class II D2; Class I; and Class II D1 with spacing were more susceptible to relapse (Al-hamdany, 2017).

The study by Cotrin et al. (2022) also investigated the causes of relapse and evaluated the impact of the mandibular third molar on relapse, specifically anterior crowding of the lower jaw, in 108 patients post-orthodontic treatment. Group 1 consisted of 72 subjects with third molars, and Group 2 included 36 patients without third molars at the post-retention evaluation stage. Panoramic radiographs and dental models of the subjects were assessed three times: before treatment, after treatment, and post-retention. Overbite and anterior mandibular crowding were measured using the Little Irregularity Index. The findings indicated that the mandibular third molar did not affect the occurrence of anterior mandibular crowding relapse in orthodontic patients (Cotrin et al., 2020).

The study by Scott C et al. (2020) aimed to evaluate the influence of gingival thickness and anatomical variations on relapse. This research was conducted on 18 individuals, consisting of 7 men and 11 women, who had undergone the extraction of at least two premolars and orthodontic treatment. The study involved 61 gingival sites post-premolar extraction. The results revealed that subjects with thicker gingiva had a higher risk of relapse (45%) compared to those with thinner gingiva (43.86%). Additionally, patients with gaps due to space closure had a higher relapse risk (42.86%) compared to patients with intact and thin gingiva (36.84%) (Stappert et al., 2020).

The use of retainers is aimed at preventing relapse after orthodontic treatment. According to Naraghi S et al. (2020), there is greater post-treatment change in patients who do not use retainers compared to those who do. This indicates that relapse after orthodontic treatment is likely to occur, and using retainers can help reduce or prevent it. In this study, two groups (retention and non-retention) were analyzed, showing an average irregularity change of 0.4 mm in the retention group and 1.3 mm in the non-retention group ($P < 0.001$). The maximum change was 2.5 mm in the retention group and 3.2 mm in the non-retention group ($P < 0.001$). Most changes in the non-retention group occurred during the 10-week interim period. The differences between the retention and

non-retention groups were statistically significant but not clinically significant (Naraghi et al., 2021).

Another study by Ishakoglu S et al. (2022) evaluated relapse after 1 year of orthodontic treatment using retainers equipped with microsensors in 42 patients. The study divided participants into two groups based on retainer wear time: short wear time (SWT; 0.9 hours/day) and long wear time (LWT; 9 hours/day). The results showed that mandibular irregularity was significantly greater in the SWT group compared to the LWT group at the end of the 12-month follow-up. No significant differences were found between the wear time groups regarding maxillary irregularity, transverse measurements, overjet, overbite, and arch length after 1 year of retention (Ishakoğlu & Çokakoğlu, 2022).

Several studies compared the use of fixed and removable retention appliances. Wiedel-Bondemark (2015) compared the stability of anterior crossbite correction in mixed dentition using fixed and removable appliances by measuring crossbite levels, overjet, overbite, and arch length on study casts before treatment (T0), at the end of the retention period (T1), and 2 years post-retention (T2). The study found that at T1, anterior crossbite correction was stable in all patients in the fixed appliance group and all but one patient in the removable appliance group. At T2, almost all treatment results remained stable and similar in both groups. Minor differences were observed between the fixed and removable appliance groups in changes in overjet, overbite, and arch length measurements from T0 to T1. These changes had no clinical implications and remained unchanged at T2 (Wiedel & Bondemark, 2015).

In comparing fixed retention appliances, Sonesson et al. (2022) evaluated three retention methods: bonded retainers on 4 upper incisors, bonded retainers on 4 upper incisors and canines, and vacuum-formed retainers (VFR) on the upper jaw. The results, assessed by changes in Little's Index and differences in contact point discrepancy (CPD) measured on digital 3D study casts at 2 years post-retention, showed that all three retention methods had good capacity to maintain upper anterior teeth. There were no statistically significant differences in anterior tooth irregularities among the three groups (Sonesson et al., 2022).

CONCLUSION

Based on the explanations above, it can be concluded that relapse is a potential occurrence following orthodontic treatment. Relapse may happen due to natural growth influenced by the forces from interdental fibers and dentogingival fibers in the periodontal tissues. Relapse can be prevented with the use of retainers.

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