

Effect of orthodontic initiation time on autotransplanted teeth outcome

Refal Almatrodi^{1*},
Gharam Alharbi²,
Shatha Aljaber¹, Ghada Alaglan³

¹BDS, College of Dentistry, Qassim University, Qassim, Saudi Arabia,

²Resident, Oral and Maxillofacial Surgery Department, Prince Sultan Military Medical City, Riyadh,

³Assistant Professor, Department of Orthodontic and Pediatric Dentistry, College of Dentistry, Qassim University, Qassim, Saudi Arabia

*Corresponding Author:

Refal Almatrodi,

E-mail: refalmatrodi@gmail.com

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ABSTRACT

Background: Tooth autotransplantation is one of the treatment options to compensate for tooth loss with the advantage of preserving alveolar bone volume and interdental papilla. Several studies have investigated the influence of orthodontic movement timing on autotransplanted teeth with different prognosis outcomes. Thus, the aim of this systematic review is to investigate the effect of orthodontic movement time on autotransplanted teeth outcomes.

Methods: A bibliographic search was carried out on PubMed, EBSCO, and Cochrane databases for English articles with no limitations in the year of publication. Eligible articles were included for data retrieval, followed by the Newcastle-Ottawa Scale for the risk of bias assessment.

Results: A total of five articles have met the inclusion criteria. The initiation of orthodontic movement timing has varied among the included studies between 4 and 8 weeks, 2 months, 6 months, and 3–9 months with different findings.

Conclusions: Autotransplanted teeth that have received orthodontic forces showed integrity in the periodontium. However, the effect of orthodontic initiation time was controversial, and further clinical studies are warranted.

Keywords: Autotransplantation, Orthodontic, Timing

Introduction

Tooth loss is a common dental finding in daily dental practice that could be attributed to trauma, dental caries, periodontitis, or agenesis. Autotransplantation, the surgical repositioning of a tooth from one site in the oral cavity to another, is a valuable treatment option with the advantage of preserving alveolar bone volume, interdental papilla, vital periodontium, and continuous eruption. Its success depends on a combination of biological, mechanical, and clinical factors that ensure proper healing, integration, and function of the transplanted tooth. A key factor is the preservation of the periodontal ligament (PDL), which is critical for maintaining periodontal health, preventing ankylosis, and ensuring long-term stability.^[1,2] Orthodontic forces also play an essential role in autotransplantation. Once the initial healing phase stabilizes the transplanted tooth, controlled orthodontic forces guide the tooth into optimal alignment, simultaneously stimulating bone remodeling.^[3,4] However, inappropriate timing

or excessive force application can disrupt healing, leading to complications such as root resorption or ankylosis.^[5] This paper explores the biological mechanisms underlying autotransplantation success, discusses their relation to the time of orthodontic force initiation, and addresses associated clinical challenges.

Materials and Methods

The methodology applied in this systematic review was based on the PRISMA guidelines.

Focus question

Does the timing of orthodontic movement affect the autotransplanted teeth outcome?

Search strategy

The following databases were independently searched: PubMed, EBSCO, and Cochrane with the following MeSH terms ((orthodontics OR orthodontic OR orthodontic patients OR orthodontic treatment OR tooth movement

OR teeth movement) AND (transplantation OR transplantations OR autogenous tooth transplantation OR autogenous teeth transplantation OR reimplantation) AND (root resorption OR tooth mobility OR tooth vitality OR survival rate OR success rate OR side effect OR collateral effects)).

Eligibility criteria of the articles

Criteria (PICO, inclusion, and exclusion) for study selection.

PICO

Participants (P) = Patients with autotransplantation of tooth

Intervention (I) = Orthodontic movement timing

Comparison (C) = Non-exposed to orthodontic movement

Outcome (O) = Effects of orthodontic movement timing on the autotransplanted tooth.

Inclusion

Studies reporting at least one of the following: Survival rate, pulp condition, mobility, presence of ankylosis, and root resorption of autotransplanted teeth with complete or incomplete root formation with a mean follow-up period of at least 1 year.

Exclusion

The exclusion criteria were as follows: Studies involving autotransplanted teeth in patients with systemic diseases, syndromes, or conditions such as cleft lip and palate; studies involving cryopreserved teeth or those maintained in culture media; studies involving autotransplantation of teeth with a history of cysts or tumors or trauma, as well as those involving sterilized teeth or the use of membranes; and studies focusing on intra-alveolar transplantation of teeth with root fractures or the presence of oro-antral fistulae or tooth autotransplantation associated with maxillary sinus lifting were excluded. In addition, animal studies, case reports, case series, opinion articles, and review articles were also excluded.

Data extraction

Two reviewers (RM) and (GH) were independently assigned to screen titles and abstracts, followed by

full-text screening for eligible articles using Rayyan software. Studies with unclear relevance were resolved by a third reviewer (GA).

The following data were extracted: Author, publication year, objectives, study design, number of participants, age, gender, autotransplanted tooth type, autotransplanted tooth condition, orthodontic initiation time, orthodontic appliance, duration of orthodontic treatment, follow-up, and results.

Quality and risk of bias assessment

Risk of bias was assessed with the NEWCASTLE Ottawa Quality assessment scale by two independent reviewers (Tables 1 and 2). Rating system ranging from 0 to 9 stars, with scores equal to or >7 considered high quality, 4–6 moderate risk, and 0–3 high risk of bias. Among the included studies, four articles scored a moderate bias risk,^[6-8,10] while one study scored a low risk of bias.^[9]

Results

A total of 653 articles were identified from the PubMed, EBSCO, and Cochrane databases. After removing duplicates, 275, a total of 378, were screened with titles and abstracts. Out of these screened articles, 23 were sought for retrieval. Three articles could not be retrieved. Twenty articles were screened and downloaded in full text for eligibility assessment. A final of 5 articles were included in this review.^[6-10] The reasons for exclusion are shown in Figure 1. The study's design, participant characteristics, and descriptions of autotransplant teeth for each study are detailed in (Table 3), along with orthodontic treatment characteristics and results in (Table 4).

Characteristics of studies

Four articles were cohorts of its design,^[6-8,10] while one article was a case control of its design.^[9] All studies have assessed the success rate of autotransplantation in conjunction with orthodontic treatment timing. Therefore, studies have relied on the assessment of periodontal status, pulpal status, root development, and ankylosis outcomes. Two studies have reported the control group with autotransplanted teeth,^[7,9] while one reported non-transplanted teeth as a control group.^[8] The other two studies^[6,10] have been based on longitudinal outcome assessment with no control group. Teeth numbers were varied with a minimum

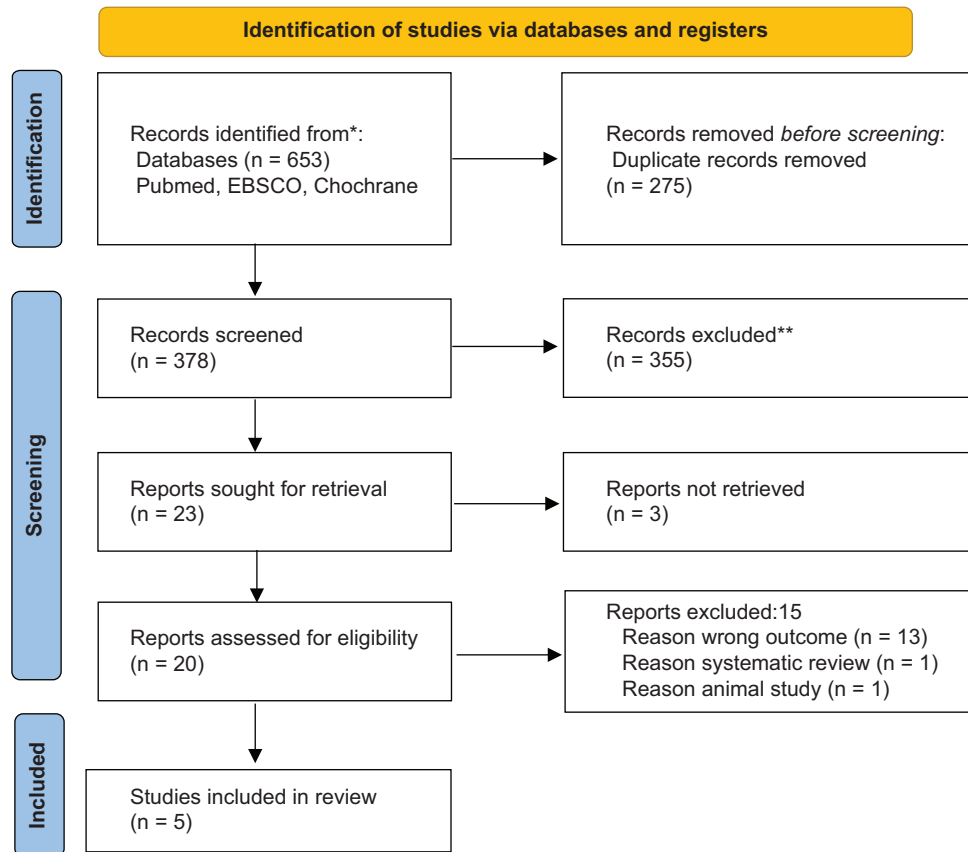


Figure 1: A flow diagram illustrating the synthesis of systematic analysis, in line with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines.

sample size of 57 teeth. None of the studies recruited sample size based on sample size calculations and study power.

Characteristics of participants

The age range of participants was 12.7–29.2 years old, with female predominance. Four studies have reported the number of participants with teeth numbers.^[6,7,9,10] In one study, they reported teeth number only.^[8] Three studies have investigated premolar autotransplantation,^[8-10] while the other two studies have reported varied tooth types such as maxillary and mandibular incisors, canine, premolars, and molars.^[6,7] A total of 288 premolars, 25 incisors, 1 canine, and 63 molars were autotransplanted. Two studies have had all the participants undergo orthodontic treatment.^[6,7] Both studies included all participants undergoing orthodontic treatment.^[6,7] Additionally, another study indicated that 29 patients received orthodontic treatment out of 59 autotransplanted premolars.^[9] While other study has reported, 39 out of 44 have been subjected to orthodontic forces.^[10] Furthermore, another study reported that 11 out of 118 autotransplanted premolars had undergone orthodontic treatment.^[8]

Characteristics of intervention

Pre-operative assessment

Studies have evaluated the pre-operative sample condition in regard to root development, ankylosis, inflammation, periodontal status, and pulpal status. None of the studies mentioned any root anomalies. All studies reported using radiographs for pre-operative assessment, with three out of four reporting the use of periapical radiographs.^[6,8-10]

Operative

Two studies have mentioned the preservation of periodontal ligaments during the surgery,^[6,9] while another study reported immediate transplantation within seconds to the recipient site.^[10] Out-of-occlusion teeth were reported by three of the included studies.^[6,7,10] Splinting methods have been reported by cobalt chromium wire with composite by one of the studies.^[7] Splinting time is also reported between 10 and 12 days.^[10] Orthodontic appliance by edgewise appliance was utilized in all five studies.^[6-10] None of the studies reported on storage media.

Post-operative

Radiographic evaluations were conducted in all studies.^[6-10] Follow-up durations were reported in most studies^[7-10] except for one,^[6] which documented a range from a minimum of 5.8 years to a maximum of 16 years.

The initiation of orthodontic treatment has varied among the studies. The earliest orthodontic treatment was reported to be within 4–8 weeks,^[7] followed by 2 months,^[6] then 3–9 months,^[8] then 6 months.^[9,10] Furthermore, Teitur *et al.* study reported ten participants subjected to orthodontic forces preceding the transplantation by 6 months.^[10] A significant correlation of autotransplantation outcome success with orthodontic treatment was reported with $P = 0.01$. Moreover, a reduction in pulp necrosis status was observed in those cases.^[8]

In cases where complete root formation with closed apical foramen was observed, all studies conducted root canal treatment for the autotransplanted teeth.^[6,9,10] However, in instances where cases showed incomplete root formation, promising outcomes were reported.^[7,8,10] Study^[7] showed no signs of inflammation in the teeth, while study^[8] reported pulp healing in 103 out of 118 teeth.

Characteristic of measurement of results

Orthodontic treatment initiated by 4–8 weeks postoperatively has reported a success rate of 93%, and abnormal findings were reported in 29 out of 100 autotransplanted teeth.^[7] The abnormal findings were reported as 15 cases with ankylosis, and 10 cases had root resorption (3 cases had both ankylosis and root resorption).^[7] In another study, orthodontic treatment was carried out by 2 months after surgery has reported a success rate of 63.1% with abnormal findings in 9 out of 33 cases.^[6] The abnormal findings were attributed to inadequate root filling.^[6] They concluded a positive success rate with early orthodontic course and adequate root filling.^[6] While, orthodontic treatment of 6 months has reported no significant complications like replacement or inflammatory root resorption. Orthodontic treatment initiated in six months has reported no significant complications, such as inflammation. However, it also showed a significant root resorption of 1–2 mm among the autotransplanted teeth in comparison with the control

group.^[9] However, complications such as periapical lesion (6 teeth), inflammatory resorption (5 teeth), crown and root fracture (2 teeth), and ankylosis (2 teeth) were documented out of 57 teeth with a median of 17.5-year follow-up period.^[10] A success rate and survival were reported to be 77% and 86%, respectively, in cases with incomplete root formation,^[10] while complete root formation cases showed lower success rate and survival rate of 79%.^[10]

A study where orthodontic treatment was initiated by 3–9 months has reported a new periodontal ligament space on the root surface.^[8] A significant case of root resorption and two cases of pulp necrosis after 5 years were also reported.^[8]

Discussion

This study was set out with the aim of investigating the effect of orthodontic initiation time on autotransplanted teeth outcome. The concerns of orthodontic movement effect have been investigated in previous studies with aplasia cases that have been treated with autotransplantation.^[2,11,12] Furthermore, autotransplantation is also commonly used as a replacement method in adolescents where implants and prosthetic procedures are not indicated. The time of initiation of orthodontic movement has been a debatable aspect in the literature. Grisar *et al.* study has reported a survival rate of 100% and a success rate of 67.5% over an average follow-up period of 28 months with orthodontic treatment starting 4 weeks postoperatively.^[13] This is consistent with Kokai *et al.*, who reported that early initiation of orthodontic treatment after periodontal healing might have a positive effect on the survival rate.^[7] On the other hand, Bauss *et al.*, have reported favorable outcomes with orthodontic treatment initiated 3–6-month post-transplant.^[14]

The root length has been utilized as a parameter effect for orthodontic movement.^[9] In addition, assessment of initial root development before transplantation might be an indicator factor for the post-operative root length.^[9] This is in agreement with the included studies,^[6-10] where all the authors have reported the tooth condition and root development in their pre-operative assessment of the cases. It has been documented in the literature that orthodontic movement is associated with root resorption at different levels.^[15,16] Slagsvold and Bjercke have reported in their study that a short root length has

Table 1: A Newcastle-Ottawa scale for case-control studies assessment.

Title	Case control								Total
	Case definition	Representativeness of cases	Control selection	Control definition	Comparability	Ascertainment of exposure	Same method for case and control	Non-response rate	
Lennart Lagerstrom	*	NR /(-)/Data not reported	NR /(-)/Data not reported	*	**	*	*	*	7

Table 2: A Newcastle-Ottawa scale for cohort studies assessment.

Title	Representativeness of exposed	Selection of non-exposed	Ascertainment of exposure	Outcome of interests not present at time of exposure	Compatibility	Assessment of outcome	Follow-up long enough for outcome to happen	Adequacy of f/u	Total
Paulsen <i>et al.</i> , Kokai <i>et al.</i> Watanabe <i>et al.</i> Jonsson <i>et al.</i>		*	*		*	*			4
			*	*		*	*	*	5
			*	*		*	*	*	5
			*	*	*	*	*	*	6

Table 3: Summary of studies general characteristic

Author	Publication year	Objectives	Study design	Number of participants	Age	Gender	Autotransplanted tooth type	Autotransplanted tooth condition
Lagerström and Kristerson ^[9]	1986	Study aimed to investigate the effect of orthodontic movement on root length completion	Case control	59 patients, 59 teeth	Mean 12.7	29 boys and 30 girls	Premolars	Immature
Paulsen <i>et al.</i> ^[8]	1995	Study was set out to investigate the pulpal, periodontal, and root development status of open foramen in orthodontically treated teeth	Cohort	118 premolars with 11 orthodontically treated	No report	No report	Premolars	3/4 to 4/4 root length with a wide open apical foramen)
Watanabe <i>et al.</i> ^[6]	2010	Study has aimed to investigate autotransplanted teeth prognosis factors based on long-term assessment	Cohort	56 patients 67 teeth	Mean: 24.1	17 female, 10 male	UI, Upper incisor; UP, upper premolar; UM, upper molar; LI, lower incisor; LP, lower premolar; LM, lower molar.	Complete root formation
Kokai <i>et al.</i> ^[7]	2015	Study was aimed to investigate the effect of early orthodontic treatment in autotransplanted teeth	Cohort	89 patients, 100 teeth	Mean: 29.1	20 male, 69 female)	Incisors, canine, premolar and molars	Complete root formation
Jonsson <i>et al.</i> ^[10]	2024	The objective of this study was to report the long-term outcome of autotransplantation of premolars to other premolar recipient sites.	Cohort	52 out of 57 teeth were subjected to orthodontic forces 39 patients out of 44 received orthodontic treatment	Mean: 13.3 years	22 female, 22 male	premolars	43 with incomplete root formation, 14 complete root formation

Table 4: Summary of orthodontic treatment characteristics and outcomes

Author	Orthodontic initiation time	Orthodontic appliance	Duration of orthodontic treatment	Follow-up	Results
Lagerström and Kristerson ^[9]	6 months	Edgewise appliance	Mean 17.8 months	No report	The findings revealed that no significant complications or inflammation were reported. However, a significant root resorption was reported.
Paulsen <i>et al.</i> ^[8]	3–9 months	Fixed appliance with elastic chains	4–6 weeks	Range 6–16 years	Orthodontic rotation was associated with significant in root resorption (1.2 mm mean). Pulp necrosis was reported in two cases out of 11 cases
Watanabe <i>et al.</i> ^[6]	2 months after surgery	Edgewise appliance	5 months	Mean 9.2 years	Findings revealed that autotransplant success is significantly associated with root filling and orthodontic movement ($P = 0.01$)
Kokai <i>et al.</i> ^[7]	4–8 weeks	Edgewise appliance	No report	5.8 years	Autotransplantation is affected by the type of donor tooth and condition. Orthodontic treatment in early phases might increase the success rate of autotransplanted teeth.
Jonsson <i>et al.</i> ^[10]	10 during 6 months preceding the transplantation 24 transplants within 6 months 18 transplants after 6 months	Conventional 0.018-in edgewise appliances	Mean 23 months	Mean 18.9 years	Of the 57 teeth, 15.8% (9 teeth) were lost over time. Eight of these lost teeth had functioned for at least 9 years post-transplant. While 48 transplants survived, 6 did not meet the success standards, leading to a total success rate of 73.7%

been observed on the premolars teeth in comparison with the control group.^[12] These findings align with Lagerström and Kristerson study.^[9]

Previous study by Slagsvold and Bjercke has reported a 100% survival rate of autotransplanted teeth with incomplete root formation.^[12] Czochrowska *et al.* reported a 90% survival rate with long-term stability over a 26.4-year observation period.^[17] In contrast, Andreasen *et al.* have reported an over 95% survival rate of autotransplanted teeth with incomplete root formation.^[1] On the other hand, a study by Jonsson *et al.* reported a survival rate of 77% and a success rate of 85% among incomplete root cases.^[10] Watanabe *et al.*, study investigated the survival rate among autotransplanted teeth with complete root formation.^[6] The findings revealed that an 86% survival rate with the recommendation of transplantation before root formation was completed when applicable. Furthermore, a study by Jonsson *et al.* has also investigated the survival rate among the complete root formation, in which they have reported 77% among the cases.^[10] Czochrowska *et al.* reported a survival rate of 90%, while the success rate was 97% over a 26.4 observation period.^[17] Similar findings were reported by Kokai *et al.*, with a 93% survival rate while the success rate was 71%.^[4] These variabilities in success rate was owing to the sample type and size, follow-up period, and success

definition.^[7] Another factor that has been investigated for its effect on the success rate is the donor teeth type.^[7] Molar teeth have recorded a success rate of 64.3 owing to the difficulty in endodontic and periodontal management or extraction and preparation of the recipient site.^[7] Root resorption has been documented to be linked to bacterial infection in the canal or damage to the cementum. However, ankylosis was associated with damage to the periodontium during surgery. On the other hand, the success rate might also be affected by autotransplantation between the jaws due to different width measurements and the difficulty of recipient site preparation.^[18]

Some studies have linked ankylosis with occlusal status, such as impacted teeth.^[19,20] Furthermore, ankylosis might also be associated with long-term rigid splinting. Thus, a splinting period of 4–8 weeks has been recommended during the initial periodontal healing. On the other hand, animal studies have shown that root resorption can be prevented by applying orthodontic movement. However, another study reported that occlusal status has no statistically significant difference in the ankylosis outcome.^[18]

To improve clinical outcomes for autotransplanted teeth and reduce risks such as root resorption or ankylosis, several guidelines are proposed. Orthodontic force

application is most effective when timed according to the healing progress. Initiating orthodontic forces 4 to 8 weeks post-transplantation is ideal when the periodontium shows good healing; research indicates a high success rate of 93%, particularly in teeth with incomplete root formation, as it supports revascularization and reduces the risk of pulp necrosis.^[7] For cases with moderate healing, approximately 2 months post-transplantation may be more suitable. However, success heavily depends on the quality of root filling and periodontal conditions.^[6] In teeth with complete root formation or those requiring extended healing, initiating forces between 3 and 9 months is beneficial to minimize the risk of ankylosis and root resorption, albeit with slightly reduced success rates compared to earlier initiation.^[10] To further reduce risks, it is critical to preserve the integrity of periodontal structures during transplantation, apply gentle orthodontic forces, conduct regular radiographic evaluations, and perform root canal therapy for teeth with fully formed roots.^[6-8,10] Additionally, thorough preoperative planning, which includes considering root development and preparing the recipient site, as well as long-term monitoring, is crucial for success.^[12,17] Splinting protocols also play a significant role; using flexible splints for 10-12 days is recommended to support initial healing while avoiding rigid or extended splinting to decrease the risk of ankylosis.^[3] By incorporating these recommendations, clinicians can optimize the timing and management of orthodontic treatment in autotransplanted teeth, leading to improved success and survival rates tailored to each patient's specific needs.

Limitations

The results of this systematic review revealed a controversial association between early orthodontic treatment timing and autotransplantation outcomes. However, the findings might be limited by the observational studies included with its potential risk of bias, and no randomized clinical trial has met the inclusion criteria of this study. Furthermore, the variability in the parameters of assessment and follow-up period resulted in data heterogeneity, which limited the meta-analysis conduction. Future research involving larger sample sizes and well-designed randomized clinical trials is warranted to validate these findings.

Conclusions

Periodontium integrity was significantly intact after the orthodontic treatment among autotransplanted

teeth. However, a definitive conclusion regarding the precise impact of orthodontic initiation time on autotransplanted teeth is controversial. Further, clinical studies with large sample sizes are warranted.

Supplementary Materials

The following supporting information can be downloaded at: www.JCDS.com/xxx/s1, Figure S1: title; Table S1: title; Video S1: title.

Authors Contributions

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Data availability statement

Not applicable.

Conflicts of interest

The authors declare no conflict of interest.

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