

Orthodontic treatment in traumatized permanent teeth: A systematic review

Tratamento ortodôntico em dentes permanentes traumatizados: uma revisão sistemática

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Abstract

Objective: to analyze, through literature review, the available literature on orthodontic treatment in traumatized permanent teeth. Methods: A literature search was performed in electronic databases (PubMed and SciELO) using the descriptors [tooth injuries] OR [injuries, teeth] OR [injury, teeth] OR [teeth injury] OR [injuries, tooth] OR [injury, tooth] OR [tooth injury] OR [teeth injuries] AND [orthodontics]. Observational studies and clinical trials were included, narrative reviews, laboratory and in vitro studies, case reports and series as well as articles that presented abstracts written in languages other than Portuguese, English and Spanish were excluded from the study. Two reviewers considered the eligibility, the risk of bias of the analyzed data and the qualitative synthesis of the studies included. A total of 1,322 references were found and 4 articles met all inclusion criteria and were included in the qualitative analysis. Some consequences like pulp necrosis and root resorption have been highlighted and trauma severity should be considered when orthodontically intervening in previously traumatized teeth. Final considerations: The traumatized teeth can be orthodontically treated as long as the time of tissue reorganization is respected, and the pull and periodontal conditions are followed up.

Keywords: orthodontics; tooth injuries; tooth movement techniques.

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Introduction

The demand of individuals for a harmonious and admirable esthetic increases daily, and for this reason, having an aligned smile is essential. Therefore, the search for orthodontic treatment to correct malocclusions has become very frequent. Several types of orthodontic appliances are used for this purpose; however, knowledge of the stomatognathic system is essential for its success. One of the main risks of orthodontic treatment that is a challenge to dental professionals is root resorption, which affects 1% to 5% of teeth subjected to forces and can have serious consequences¹.

Although biological factors are intrinsic to the patient, other factors such as dental trauma and the use of an ideal force in the orthodontic technique need to be taken into account to minimize the risks of orthodontic treatment, as they can lead to tooth loss. The type, direction of force, and time of application of the same also need to be evaluated^{1,2}.

According to the literature, 10.8% of patients who need orthodontic treatment have already experienced some type of dental injury, which requires even greater care when orthodontically moving the previously traumatized teeth³. Since one of the sequelae of dental trauma is inflammatory resorption, applying orthodontic forces to teeth that have some resorption focus makes the prognosis of the traumatized teeth and the success of orthodontic treatment uncertain².

Petti *et al.*⁴ (2018), reported that traumatic dental injuries account for 85% of patients with some type of lesion in the oral region, demonstrating the high frequency of dental trauma in the society. This confirms that it is quite easy to experience dental trauma, since it occurs due to falls, car accidents, aggressions, and other types of severe collision with the teeth^{5,6}. The upper central incisors have the highest prevalence of these injuries, just as the males have a higher prevalence with a sex ratio of 2.4: 1 ratio. In addition, the age group with the highest incidence of these injuries is between 13 and 19 years old, decreasing after the second decade of life⁶.

Therefore, this study aimed to systematically review the available literature on the possible complications of orthodontic treatment on traumatized permanent teeth.

MATERIALS AND METHODS

This study was conducted using the Preferred Report items for Systematic Review and Meta-analysis (PRISMA)⁷. The focused question addressed was: "What are the possible complications of an orthodontic treatment on traumatized permanent teeth?"

Electronic surveys were conducted in April 2019 and updated in October of the same year in the databases; PubMed and SciELO and all the studies available up to that date were considered. The descriptors used for the PubMed and SciELO platforms were [tooth injuries] OR [injuries, teeth] OR [injury, teeth] OR [teeth injury] OR [injuries, tooth] OR [injury, tooth] OR [tooth injury] OR [teeth injuries] AND [orthodontics]. Duplicate articles were removed.

The following inclusion criteria were established: observational studies (cohort, cross-sectional, or case-control) and clinical trials (randomized or not) among individuals who underwent orthodontic

treatment with mixed or permanent dentition and who had any permanent teeth with a history of any type of dental alveolus trauma, without limit in relation to the period of occurrence. Only articles published in Portuguese, English, or Spanish were included. Narrative reviews, laboratory and in vitro studies, case reports, and case series were excluded, as were articles referring to primary dentition and the use of orthopedic appliances or that were not related to traumatized teeth.

Two researchers evaluated the articles found in the searches independently and selected those that met the inclusion criteria. In cases of disagreement, a third evaluator made his assessment. The selected studies were read in full, and those that met the inclusion criteria were selected. After selection, the references of the included articles were analyzed in order to identify other possible studies related to the research question.

All the included studies were submitted to a qualitative analysis. Thus, after the selection, the two researchers independently extracted the data collected from the included studies; the following data were extracted: author, type of study, sample, sex, outcome, time between trauma and beginning of orthodontic treatment, type of trauma assessed, follow-up of orthodontic treatment, trauma follow-up, and main results. Analysis of the bias risk in the included studies was performed. This study was based on the guidelines for synthesis without meta-analysis (SWiM), developed to guide reviews of interventions in which the meta-analysis of effect estimates is not possible or cannot be performed⁸.

Results

A total of 1316 articles in PubMed and 6 articles in SciELO were identified. After removing duplicates, a total of 1321 articles were evaluated by title and abstract. After this step, 1291 articles were excluded because they are irrelevant to the question, and 30 articles were left. After the final selection stage, 26 articles were excluded: 19 because they did not correspond to the design, 7 due to the absence of the study outcome, and 4 articles were included and processed for data extraction⁹⁻¹². Figure 1 shows the identification flowchart according to PRISMA with the reasons for excluding the studies and the Table 1 summarizes the data collected.

Figure 1. PRISMA flow diagram for studies retrieved through the searching and selection process.

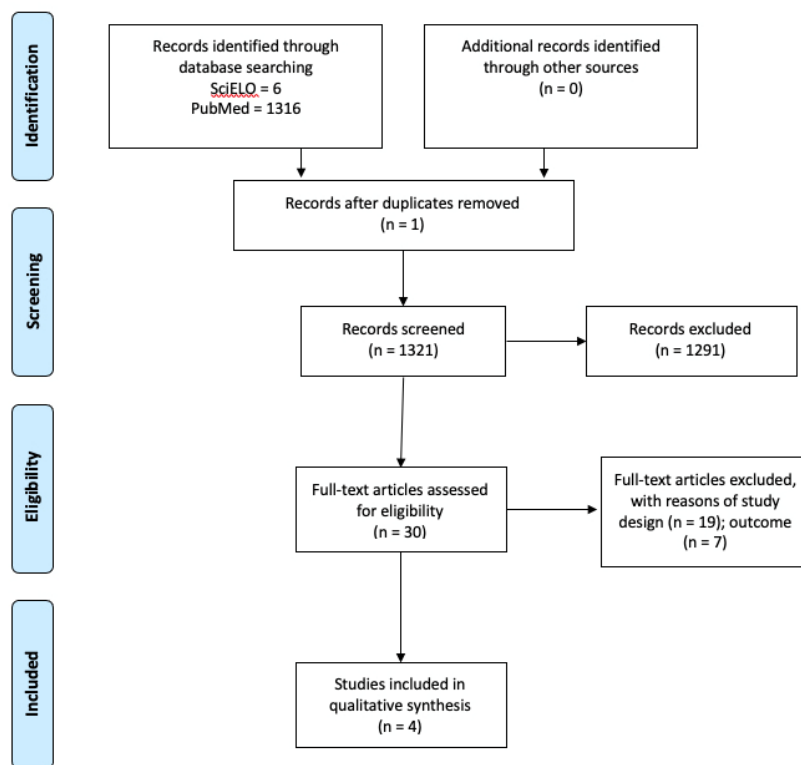


Table 1 – Characteristics of the included studies in the final review. [† traumatized teeth with orthodontic treatment (TO); †† teeth with orthodontic treatment (O); ††† traumatized teeth (T); †††† control group (C)].

Reference, Country	Study design	Sample (n)	Gender (n)	Outcome	Time interval between trauma and onset of orthodontic strength	Traumatic dental injury	Orthodontic follow-up (mean)	Trauma follow-up (mean)	Main results
Bauss et al. (2009/ Germany)	Observational retrospective study	TO†:59 O††:800 T†††:193 Total:1052 teeth	TO: 18F, 28M O: 60F, 140M T: 61F, 112M	To analyze pulp vitality in teeth that have suffered trauma during orthodontic treatment	Mild trauma: 2 -3 meses Severe trauma: 5-6 meses	TO and T: enamel fracture, enamel-dentin fracture, subluxation, extrusion, lateral luxation e intrusion	TO: 9 months O: 2,1 years T: not applicable	TO: 13, 4 months O: not applicable T: 5,4 years	- TO group has a high pulp necrosis frequency; - Teeth with pulp injury have a shorter treatment time; - 34.8% of the teeth with severe periodontal lesion had total pulp obliteration; - Teeth with total pulp obliteration show a higher necrosis frequency.
Bauss et al. (2008/ Germany)	Observational retrospective study	TO: 186 patients, 269 teeth	TO: 56F, 130M O: 60F, 140M T: 61F, 112M	To analyze the influence of orthodontic intrusion on pulp	Mild trauma: at least 3 months	TO and T: enamel fracture, enamel-	TO: 3,2 years O: 3, 4 years T: not applicable	TO: not available data O: not applicable T: 5, 5 years	- The TO group has a high pulp necrosis frequency;

		O: 200 patients, 800 teeth T: 173 patients, 193 teeth Total: 579 patients		vitality of teeth with previous trauma	Severe trauma: 1 year	dentin fracture, subluxation, extrusion, lateral luxation e intrusion			- The highest frequency of pulp necrosis was found in severe periodontal lesions and at the beginning of the orthodontic intrusion movement.
Bauss et al. (2008/ Germany)	Observational retrospective study	TO: 269 teeth C++++: 193 teeth.	TO: 56F, 130M C: 61F, 112M	To determine the influence of pulp obliteration on pulp vitality during the orthodontic intrusion movement of previously traumatized teeth	Mild trauma: at least 3 months Severe trauma: 1 year	TO and C: enamel fracture, enamel-dentin fracture, subluxation, extrusion, lateral luxation e intrusion	TO: 3,2 years C: not applicable	TO: 3,2 years C: at least 3 years	- TO group with higher necrosis rate; - Teeth with total obliteration had a significantly higher frequency of pulp necrosis; - Teeth with total pulp obliteration showed a higher rate of pulp necrosis during the intrusion period compared to the other treatment phases.
Malmgren et al. (1982/ Sweden)	Case-control	TO: 27 patients, 55 teeth C: 55 patients	TO: 12F, 15M C: 34F, 21M	Assess the risk of root resorption after orthodontic movement of previously traumatized teeth	From 5 months to 2 years	Not complicated crown fracture, complicated crown fracture, concussion, subluxation and luxation	Not available data	Not available data	- Teeth traumatized with root resorption before treatment suffered more resorption during treatment than teeth without these signs; - Teeth with mild or moderate trauma and a healthy periodontium with an observation period of at least 4 to 5 months can be moved with a prognosis comparable of non-traumatized teeth.

Three retrospective studies⁹⁻¹¹ and one case-control study¹² were included in this review. In all studies traumas that occurred to the teeth and periodontal ligament were evaluated⁹⁻¹². In the studies by Bauss *et al.*^{10,11} (2008, 2008), the same samples were used, composed of Class II, Division 1 patients with severe overbite; however, different outcomes were evaluated, including the influence of orthodontic intrusion on pulp vitality and the effect of pulp obliteration on pulp vitality, respectively. In these studies^{10,11} and in the study by Malmgren *et al.*¹² (1982) (teeth that had undergone trauma prior to the orthodontic treatment were analyzed, with a difference between their outcomes. Malmgren *et al.*¹² (1982), evaluated the degree of resorption experienced by these teeth, while Bauss *et al.*^{10,11} (2008, 2008), analyzed the pulp conditions. In the study by Bauss *et al.*¹⁰ (2008), the influence of orthodontic intrusion on the pulp vitality of traumatized teeth and orthodontically-treated teeth was evaluated. In the other study, Bauss *et al.*¹¹ (2008), evaluated pulp vitality in traumatized and orthodontically-treated teeth with different degrees of pulp obliteration (absent, partial, and total).

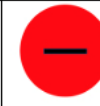
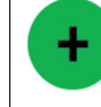
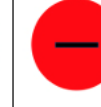
In the study by Bauss *et al.*⁹ (2009), they instead evaluated the pulp conditions of teeth that had experienced trauma during orthodontic movement.

The time between trauma and the beginning of the orthodontic strength ranged from 2 months to 2 years, depending on the type of injury⁹⁻¹². The average follow-up time for the orthodontic treatment ranged from 9 months to 3.4 years⁹⁻¹¹ and in the study by Malmgren *et al.*¹² (1982), this information was not available. The average follow-up time for the traumatized teeth ranged from 13.4 months to 5.5 years⁹⁻¹¹ and the study by Malmgren *et al.*¹² (1982) still did not have this information. The average age of the patients at the time of trauma ranged from 7-15 years, and the average age of patients when they started orthodontic movement ranged between 11.2 to 13.10 years⁹⁻¹¹ however, the study of Malmgren *et al.*¹² (1982), did not provide this information.

The analyzed studies selected to answer the question in this review demonstrated the following: traumatized and orthodontically-moved teeth have a higher rate of pulp necrosis⁹⁻¹¹ the highest frequency of necrosis occurred in the period of orthodontic intrusion^{10,11} and in the traumatized teeth that presented root resorption prior to the orthodontic treatment, I worsened after the start of the orthodontic movement¹². It was also shown that teeth traumatized during orthodontic movement that had severe periodontal lesions, had total pulp obliteration in 34.8% of cases⁹. In addition, teeth with total pulp obliteration had a higher rate of pulp necrosis than teeth without obliteration or with partial pulp obliteration^{9,11}.

A total of four studies⁹⁻¹² were evaluated according to the methodology of Martins *et al.*¹³ (2017), and all of them presented a high risk of bias, as shown in Figure 2.

Figure 2. Methodological quality assessment for each included study with low risk of bias (green) or high risk of bias (red).

	Rp	IEc	Lf	Me	Sa	O
<u>Bauss et al.</u> ⁸ 2009						
<u>Bauss et al.</u> ⁹ 2008						
<u>Bauss et al.</u> ¹⁰ 2008						
<u>Malmgran et al.</u> ¹¹ 1982						
Risk of bias legend Rp Bias arising from the randomisation process IEc Definition of inclusion and exclusion criteria Lf Reporting of loss to follow-up Me Validated measurements Sa Statistical Analysis O Overall risk of bias						

Discussion

The present study aimed to systematically review the available literature on the possible consequences of orthodontic treatment on traumatized permanent teeth. Very few studies on this topic are reported in the literature, and only four articles were included in this review: three⁹⁻¹¹ of them evaluated pulp conditions and only one¹² evaluated root resorption. Due to this divergence of outcomes, as well as the small number of studies, it was not possible to perform a quantitative analysis, thus hampering a robust interpretation of the findings.

The evaluated studies discussed different types of trauma and classified them in two large groups: mild trauma (enamel fracture, dentin enamel fracture, concussion, and subluxation) and severe trauma (intrusive, extrusive, and lateral dislocations). However, only three articles⁹⁻¹¹ two of which used the same sample, associated the type of trauma with the starting or continuation time of the orthodontic strength; for minor trauma the minimum time was 2 to 3 months and for severe trauma from 5 months to 1 year. The fourth article included did not specify the type of trauma, but the suggested time was between 5 months and 2 years. There seems to be a consensus regarding the conduct to wait for a latency period so that tissue reorganization can occur until orthodontic forces can be (re) inserted, since these ideal forces are used for adequate tooth movement, which are sufficient to generate movement without causing damage; however, forces beyond these can cause some damage to the dental and periodontal structures¹⁴.

The studies conducted by Bauss *et al.*⁹⁻¹¹ (2008, 2008, 2009), showed that teeth traumatized previously or during orthodontic treatment had a higher rate of pulp necrosis. In addition, teeth with total pulp obliteration showed higher rates of necrosis when compared to teeth with partial pulp obliteration or without obliteration. Traumatized teeth with severe periodontal damage experienced damage to the apical vessels that can be permanent, thereby reducing the blood supply of these teeth¹⁵. According to some studies, there is initially a reduction in pulp blood flow during conventional orthodontic movement, but this is soon compensated by a hyperemic reaction^{9,16}. In traumatized teeth with poor pulp blood flow, there is no way to compensate for the lack of tissue perfusion that occurs in orthodontic movement, making these teeth more prone to pulp necrosis. This is also the case for teeth with total pulp obliteration, since the formation of calcified tissue inside the pulp constricts the vessels and impairs the blood supply¹⁵.

There was a higher rate of pulp necrosis in teeth with severe periodontal injury, especially at the beginning of the orthodontic intrusion movement^{10,11}. The orthodontic intrusion movement has a greater impact on the apical region, thus contributing to the blood flow reduction that will be damaged if it is a tooth with severe periodontal damage^{17,18}. It was noted again that the group of traumatized teeth that moved orthodontically had a faster intrusion movement than the group of teeth without trauma, without any justification on the part of the author. This was surprising, since it is expected that the traumatized teeth will be moved with greater caution and care¹⁰. Traumatized teeth without pulp obliteration or partial pulp obliteration are able to compensate for the blood flow reduction

generated during the intrusion movement, whereas in teeth with total pulp obliteration, there is no such compensation, resulting in a higher pulp necrosis rate^{11,15}.

One of the selected articles showed that the treatment time for traumatized teeth in the presence of pulp necrosis was approximately half the orthodontic treatment time when compared to the treatment time for teeth without trauma and pulp necrosis, suggesting that the faster treatment may have more forces and causes more damage⁹. There were also a greater number of arch changes in teeth with pulp necrosis. The article did not justify why more frequent arch changes were made in a short period of time; it just explains that this caused greater apical compression by decreasing the vascular supply and that it may also have helped in the progression of pulp obliteration resulting in pulp necrosis and contributing to the fact that the group treated orthodontically had a higher rate of necrosis¹⁷.

Only a single study addressed one of the most recurrent consequences of orthodontic treatment: root resorption, which during a conventional treatment is caused by the inflammation induced by an orthodontic load, and in turn causes resorption of the cement, and can extend to the underlying dentin, aggravating external resorption, and may result in permanent loss of the root length^{12,20}. Resorption is a sequel to traumatized teeth²¹ therefore, it was believed that orthodontically moving a traumatized tooth would increase the chances of the root resorption of that tooth. However, the study showed that only teeth that presented signs of root resorption prior to treatment underwent significant resorption during movement compared to those without these signs. Due to the fact that root resorption is a common sequela of conventional orthodontic treatment, it was surprising that only one article reported it as a complication of orthodontic treatment on traumatized teeth and the same was included in this review. However, the importance of good health provider-patient communication is emphasized, where the possibility of the appearance of root resorption and its consequences must be made very clear to the patient, especially if an orthodontic treatment is performed on teeth that already show signs of resorption.

One of the limitations of this study is that the systematic review found only four articles that met the inclusion criteria, and of these, three were from the same author, with the same line of thought. Due to this reason and because the samples had the same "n" we noticed that the articles⁹⁻¹¹ had the same sample of traumatized teeth (193 teeth), of orthodontically-moved teeth^{9,10} (800 teeth), and of previously traumatized and orthodontically-moved teeth^{10,11} (269 teeth). Another limitation of the studies is in relation to the follow-up period, where the maximum follow-up time was 5 years, and one of the articles did not provide this information¹². Periodic monitoring of the traumatized teeth is extremely important in order to assess the success of the treatment performed and the possible sequelae on the affected tooth/teeth³.

It is difficult to objectively answer the main question of this study because a randomized clinical study would be required. A randomized trial is inconceivable in this case because it is ethically unfeasible to randomize patients to alveolodental injuries; these injuries are very diverse, have different causes, intensities, and extensions. Therefore, since many patients who seek an orthodontic correction of their smiles have experienced some form of alveolodental trauma, it is necessary to

explain to the patient the possible consequences of the treatment and care that aims to reduce the appearance of sequelae, so that the patient can make an informed decision on whether to undergo the treatment or not. It is also indicated that clinical and radiographic follow-up should be done at shorter intervals, so that a thorough analysis of the tissues and their possible changes are performed. It is suggested to carry out further studies on the consequences of orthodontic treatment on traumatized teeth, with longer follow-up times.

Conclusion

Traumatized teeth can be treated orthodontically as long as the time for tissue reorganization is respected and the pulpal and periodontal conditions are observed. The patient should be well informed about the possible consequences of the treatment, as some outcomes were observed, such as pulp necrosis and root resorption. The severity of the trauma must always be taken into account because the more severe the trauma, the worse the prognosis.

Resumo

Objetivos: analisar, por meio de revisão de literatura, a respeito do tratamento ortodôntico em dentes permanentes traumatizados. Metodologia: Uma pesquisa bibliográfica foi realizada em bancos de dados eletrônicos (PubMed e SciELO) usando os descritores [tooth injuries] ou [injuries, teeth] ou [injury, teeth] ou [teeth injury] ou [injuries, tooth] ou [injury, tooth] ou [tooth injury] ou [teeth injuries] e [orthodontics]. Foram incluídos estudos observacionais e ensaios clínicos, revisões narrativas, estudos laboratoriais e in vitro, relatos de casos e séries, bem como artigos que apresentassem resumos redigidos em idiomas diferentes do português, inglês e espanhol foram excluídos do estudo. Dois revisores consideraram a elegibilidade, o risco de viés dos dados analisados e a síntese qualitativa dos estudos incluídos. Foram encontradas 1.322 referências e 4 artigos atenderam a todos os critérios de inclusão e foram incluídos na análise qualitativa. Algumas consequências como necrose pulpar e reabsorção radicular têm sido destacadas e a gravidade do trauma deve ser considerada na intervenção ortodôntica em dentes previamente traumatizados. Considerações finais: Os estudos incluídos nesta revisão sugerem que dentes traumatizados podem ser tratados ortodônticamente desde que respeitado o tempo de reorganização tecidual e acompanhadas as condições pulpares e periodontais.

Palavras-chave: ortodontia; traumatismos dentários; técnicas de movimentação dentária.

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