Orthodontic treatment recommendation and expected adverse reactions in patients with a history of dental trauma: a survey among general dentists, paediatric dentists and orthodontic specialists

Running title

Orthodontic treatment of traumatized teeth

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G.V.G, G.W and D.D. designed the research setup; N.B., Vh.I. and G.V.G. collected the data; G.V.G and D.D. analysed and interpreted the data; G.V.G. drafted the paper; and all authors critically revised the manuscript prior to its submission.

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Orthodontic treatment recommendation and expected adverse reactions in patients with a history of dental trauma: a survey among general dentists, paediatric dentists and orthodontic specialists

Summary

Background: Trauma-induced adverse reactions may trigger complications when moving teeth orthodontically.

Aim: The purpose of this study was to evaluate the knowledge of dental practitioners about this topic.

Design: A questionnaire survey was organized among general dentists, paediatric dentists and orthodontists in Flanders (Belgium). Three clinical cases describing trauma-induced tooth damage (tooth ankylosis, apical root resorption and pulp/root canal obliteration) were presented, followed by a set of questions.

Results: The questionnaire was completed by 121 general dentists (GD), 47 paediatric dentists (PD) and 99 orthodontic specialists (OS).

In the case with ankylosis, impossibility to move the tooth orthodontically was reported as most frequent adverse reaction (82.8% of GD, 95.7% of PD and 100.0% of OS) ($P<0.001$). In the situation of apical root resorption, the most frequently reported adverse event was progressive apical root resorption (78.9%, 85.7% and 88.8% respectively) ($P=0.265$). Most frequently mentioned adverse reaction in the case with pulp and root canal obliteration was tooth discoloration (64.1%, 57.1%, 78.3%) ($P=0.055$), followed by apical root resorption (57.4%, 56.8%, 68.7%) ($P=0.283$).

Orthodontic treatment recommendation differed among specific clinical situations but also among groups of dental practitioners.

Conclusions:

Important knowledge gaps exist regarding the orthodontic management of traumatized teeth. This topic requires more attention in undergraduate training, specialist training and continuing education.

Key words:

Dental trauma, orthodontic tooth movement, ankylosis, apical root resorption, pulp obliteration

Introduction

Orthodontic tooth movement can be accompanied by side effects and complications, not only during the active phase of therapy but also after completion of the treatment. Some of these reactions, such as gingivitis and external apical root resorption, are reversible or self-limiting in nature and therefore without important longterm clinical implications¹. Other reported adverse events may lead to complications, necessitating additional treatment or even compromising tooth survival. These situations include pulpal reactions and external cervical resorption^{2,3}. Since most of these reactions occur in front teeth, their impact is considerable.

Several risk factors have been associated with the occurrence of these adverse reactions, including a history of dental trauma⁴. In the latter situation, most frequently reported complications are an increased risk for external root resorption, pulp necrosis, pulp obliteration and ankylosis⁵⁻⁹.

Since an estimated 10% of young patients presenting for orthodontic treatment has a history of dental trauma¹⁰, often involving upper incisors situated in the esthetic zone, it is important to integrate this information in the orthodontic management approach⁴. Kindelan et al. published an overview of the influence of dental trauma on the management of orthodontic treatment and which factors the orthodontic specialist should consider when contemplating movement of traumatized teeth¹¹.

From the above it is clear that dental practitioners should be aware of possible complications that might occur when moving teeth with a history of dental trauma. This is not only the case for orthodontic specialists treating those patients, but also for general dentists and paediatric dentists referring patients for orthodontic treatment or following up these patients during and after active treatment.

Currently, it is unclear how dental practitioners deal with these cases in daily practice and what their knowledge is about the impact of adverse reactions after dental trauma on possible complications when moving these teeth orthodontically. The present study investigates these aspects among orthodontic specialists, general dentists and paediatric dentists in specific situations of trauma-induced tooth ankylosis, apical root resorption and pulp/root canal obliteration.

Material and methods

A questionnaire survey was organised among general dentists, paediatric dentists and orthodontists in Flanders (Belgium) as part of a larger survey on the topic of orthodontic treatment in patients with a history of dental trauma.

Questionnaire

Personal characteristics of the respondents, including gender, number of years practicing dentistry and their exposure to patients with dental trauma, were collected and three clinical cases were presented. Each of them described the clinical situation of a traumatic incident in a young patient with impact on one or more immature front teeth. The information included a brief history of the traumatic event, photographs of the clinical situation and a selection of radiographic images. Each case description was followed by a set of questions. These explored whether the dental practitioner would recommend orthodontic treatment for this patient (no, rather not, maybe, probably, certainly). In addition, the practitioner was asked about the type of adverse reactions expected to occur when orthodontic forces would be applied on the traumatized tooth (set of proposed answering categories to be completed with yes, no or no idea) (for more details, see tables 1-3). Following clinical conditions were included: 1) a case with tooth ankylosis after re-implantation of an avulsed upper incisor (Figure 1); 2) a case with apical root resorption after uncomplicated crown fracture of a central upper incisor (Figure 2); and 3) a case with pulp and root canal obliteration of a central upper incisor after lateral luxation injury (Figure 3).

The questionnaire and clinical case presentations were validated by a group of seven paediatric dentistry trainees and clinical instructors. They provided remarks and suggestions regarding content and clarity of formulation of the questions. Based on this information, the questionnaire was further refined.

Participants

Dental practitioners were approached at the occasion of widely attended meetings organized by their respective professional organisations. For general dentists this took place at the occasion of the annual autumn meeting organized by the alumni association of dentists that graduated from the University of Leuven (KU Leuven) (*Leuvense Universitaire Tandheelkundige Vereniging, LUTV*), (November 2016). The questionnaire was handed out to the participants at the beginning of the event, as part of the conference documents. Participants were asked to complete the document during the meeting and the

questionnaires were collected back by some volunteering students at the end of the meeting. Paediatric dentists were surveyed at the occasion of the annual member symposium organized by the Belgian Academy of Paediatric Dentistry (BAPD) (November 2016). For distribution and collection of the questionnaires, exactly the same procedure as described above was followed. Orthodontists were approached at the occasion of the Ortholeuven symposium organized by the KU Leuven department of Orthodontics (November 2016) and at the spring meeting of the *Belgische Beroepsvereniging van Nederlandstalige Orthodontisten* (BBNO) (February 2017). Again, a similar way of distribution and collection of the questionnaires was used. Participants of the second event were clearly instructed not to complete a second questionnaire if they already had done so at the first occasion.

Analysis

Questionnaire data were entered in a database using Excel 2013 (Microsoft). Summary statistics and comparison of results obtained in the different groups of dental practitioners were derived using the tools provided in this software program. Chi-square tests were applied for categorical variables and Student's t-tests for continuous variables.

Ethical clearance was obtained (registered under mp16590 for the survey in general dentists and mp 13759 for the surveys in paediatric dentists and orthodontists).

Results

Characteristics of the respondents

The questionnaires were completed by 121 general dentists, 47 paediatric dentists and 99 orthodontic specialists, representing 34%, 71% and 63% of those attending the respective meetings. Most participants were female, accounting for 64.5%, 68.1% and 74.7% of the respondents. Over 40% of general practitioners (43.3%) reported more than 30 years of clinical experience, but also young general dentists were well represented with about one out of three (32.5%) reporting less than 10 years of clinical practice. In paediatric dentists, a large group of participants (46.8%) reported having less than 5 years of clinical experience. In orthodontic specialists, the distribution over the different age categories was more even with the largest group (28.3%) reporting between 21 and 30 years of professional experience.

Tooth ankylosis

Table 1 summarizes the answers obtained among the three groups of dental practitioners regarding orthodontic treatment recommendation and expected complications in case of orthodontic movement of a tooth showing ankylosis after traumatic injury. While general dentists would recommend orthodontic treatment in this situation rather not (42.9%) or maybe (31.3%), paediatric dentists are more reluctant and recommend treatment less frequently (28.3% rather not, 26.1% maybe and 24.0% certainly not). The distribution of answers provided by the orthodontic specialists shows a different pattern with 45.8% recommending treatment probably and 21.9% certainly in this situation ($P<0.001$).

About two thirds of general and paediatric dentists (67.1% and 65.5%, respectively) and more than three quarters of orthodontists (78.7%) expected adverse reactions to occur upon orthodontic tooth movement in this situation. Impossibility to move the tooth orthodontically was reported as most frequent adverse reaction by orthodontists (100.0%), paediatric dentists (95.7%) and general dentists (82.8%). This was followed by external cervical resorption (50.0%, 65.8% and 69.8%, respectively) and apical root resorption (45.6%, 62.5% and 67.0%). Inflammatory root resorption and apical pathology were mentioned less frequently. Tooth discoloration was reported least often (20.9%, 10.5% and 25.0% respectively).

Apical root resorption

Table 2 describes the answers regarding orthodontic treatment recommendation and expected complications in case of orthodontic treatment of a tooth showing apical root resorption after traumatic injury.

Hesitation for recommending orthodontic treatment is lower than for the situation of tooth ankylosis, in all three groups of dental practitioners. While general dentists and paediatric dentists reported most frequently that they maybe would recommend treatment (38.3% and 51.1% respectively), orthodontists most often answered that they would probably treat this patient (48.0%) ($P<0.001$).

Adverse reactions upon orthodontic tooth movement were expected to occur in this situation by about half of general dentists and orthodontists (55.0% and 51.0% respectively) and up to three quarters of paediatric dentists (75.9%). A considerable number of respondents replied they did not know the answer, amounting to 31.7% in general dentists. Apical root resorption was reported most frequently as adverse event, by all three groups of dental practitioners (88.8% of orthodontists, 85.7% of paediatric dentists and 78.9% of

general dentists). Further, almost all proposed possible adverse events were mentioned by the respondents, with frequencies between 43.8% (for inflammatory root resorption, reported by general dentists) up to 78.6% (for apical pathology reported by paediatric dentists and tooth discoloration by orthodontists). The only exception was impossibility to move the affected tooth. This adverse reaction was reported by 11.3% of general dentists, 13.5% of paediatric dentists and 33.8% of orthodontists ($P<0.002$).

Pulp and root canal obliteration

Table 3 presents the results regarding orthodontic treatment recommendation and expected adverse reactions in case of orthodontic treatment of a tooth presenting pulp and root canal obliteration after traumatic injury.

In this situation, hesitation was lowest with around half of general practitioners and paediatric dentists (51.0% and 48.9%) and three quarters of orthodontists (76.3%) indicating they would recommend treatment probably or certainly ($P<0.001$).

Adverse reactions were expected by 44.9% of orthodontists and 71.0% of paediatric dentists, while general dentists presented a more diverse answering pattern with a large proportion of them indicating that they had no idea (39.0%) ($P<0.002$). Overall, the most frequently mentioned adverse reaction was tooth discoloration (64.1%, 57.1% and 78.3%), followed by apical root resorption (57.4%, 56.8% and 68.7%). The occurrence of pulp necrosis was mentioned by somewhat more than half of the respondents (57.1%, 52.5% and 59.0% respectively, in general practitioners, paediatric dentists and orthodontists) ($P=0.731$). This was comparable to the answers regarding the development of apical pathology (51.6%, 56.1% and 60.0%). Orthodontists indicated impossibility to move the affected tooth in this situation more often than other dental practitioners did (29.7% versus 19.5% and 7.3%) ($P=0.012$).

Discussion

Orthodontic treatment recommendation in patients with dental trauma history differs among clinical situations¹², but also among groups of dental practitioners¹³. In the present study, orthodontic specialists clearly showed least hesitation for orthodontically moving traumatized teeth. This seems somewhat surprising since they reported at the same time a considerable number of potential adverse reactions, in each of the presented clinical situations. Possibly, they incorporate this in their orthodontic management plan from the

start and do not consider this as an absolute contra-indication for orthodontic tooth regulation. General dentists are most hesitant for recommending orthodontic treatment in these patients. This finding is confirmed by the high number of answers stating that they did not have an idea about the possible occurrence of the different adverse events and by the considerable number of missing answers. Paediatric dentists are less reluctant for recommending orthodontic treatment, except for the situation of tooth ankylosis where about one out of four would certainly not recommend treatment. The latter can probably be ascribed to a more strict interpretation of the question, not considering a modified orthodontic treatment plan.

When the different clinical situations are compared, hesitation is largest in a situation of tooth ankylosis and least in case of pulp and root canal obliteration.

In a situation of tooth ankylosis, impossibility to move the tooth orthodontically was well recognized by the respondents. This reaction is well documented in the literature^{7,14}. Following a severe injury of the periodontal membrane (eg in case of intrusive luxation or replantation after tooth avulsion) fusion of the mineralized root surface (cementum or dentin) with the alveolar bone will occur. This will result in progressive replacement of the root structure by bone (replacement resorption)¹⁵. In the absence of a periodontal ligament orthodontic tooth movement is not possible⁷. Surprisingly, about one out of six general dentists was not aware of this. This might point to a shortage in the undergraduate education of the dental practitioners. Specialist training, both for orthodontic and paediatric dentists, clearly covers this topic. Other adverse events frequently mentioned in this situation were external cervical resorption and apical root resorption, reactions not typically linked to tooth ankylosis¹⁵. Other adverse events mentioned, but to a lesser extent, were apical pathology and tooth discoloration, but relevant literature in relation with ankylosis is not available.

In the second clinical case, the tooth affected by the traumatic event presented apical root resorption. This reaction occurred in a tooth with uncomplicated crown fracture. A large majority of the respondents indicated that further apical resorption is to be expected when orthodontic forces are applied to the tooth. Indeed, the presence of apical root resorption before start of orthodontic treatment is accompanied by a high risk for further breakdown of the root in the apical region⁵. The underlying mechanism for this reaction remains unexplored. Apical root resorption is a common complication of an orthodontic treatment,

with injury originating from the pressure applied to the roots during tooth movement¹⁶, resulting in loss of root structure involving the apical region¹⁷.

Further, a wide variety of possible adverse events (inflammatory root resorption, apical pathology, tooth discoloration) was indicated by the respondents, without large differences among the different groups of practitioners. Remarkable was the relative high number of orthodontists (one out of three) reporting that teeth with apical root resorption are impossible to move orthodontically. The above illustrates the presence of a lot of confusion and uncertainty, even among orthodontists. This clearly needs more attention in the training of dental professionals.

The third clinical situation considered pulp and root canal obliteration. This reaction occurred after lateral luxation injury. Pulp canal obliteration, also called calcific metamorphosis, can occur as a sequela of dental trauma and has been reported to develop most often in immature teeth with extrusive and lateral luxation injuries^{18,19}. Literature mentions pulp necrosis and apical pathology as findings linked to the orthodontic movement of teeth affected by this condition²⁰. Progressive obliteration implies reduction of the pulpal blood supply²¹. Traumatized teeth with total pulp obliteration have a higher susceptibility to pulpal complications during orthodontic intrusion than traumatized teeth without or only partial pulp obliteration²².

Pulp necrosis and apical pathology were reported adverse events by only slightly more than half of the respondents, without relevant differences among the different groups of practitioners, indicating an important knowledge gap. Also remarkable was the high frequency of apical root resorption mentioned as a possible adverse event since literature does not confirm this finding^{23,24}.

Noteworthy is also the finding that a considerable number of orthodontists replied that it would not be possible to move the affected tooth, both in the clinical situation of apical root resorption and in the case of pulp obliteration. This might be explained by the fact that they interpreted the question differently not indicating that it would be technically impossible to move the tooth but rather that they would anticipate possible complications of the orthodontic treatment by not applying forces to the affected tooth, and thus not move the tooth.

Overall, there seems to be confusion regarding the different types of resorptive processes that can occur. This is illustrated by the high scores for apical root resorption, external

cervical resorption and inflammatory root resorption as possible complications. The use of different terms and classifications of root resorption in the literature creates also confusion¹⁶.

In the present survey, response levels were good in both paediatric dentists and orthodontic specialists and moderate in general dentists. Gender and age distribution reflected the overall situation in the respective professional groups very well. The only exception was the relative high proportion of young paediatric dentists; the latter being the result of the high attendance rate of recently graduated specialists within this field of expertise. A more in depth exploration of the impact of gender, age and university of graduation would require larger numbers of participants. Of course, it cannot be excluded that dental practitioners attending scientific meetings are those most interested in continuing education and therefore they might be more knowledgeable than the general population of dental professionals. As a consequence, the results presented in this report overestimate knowledge rather than the opposite. It is important to mention that the topics of the different meetings where the survey took place were not related to the subject of this survey.

Conclusions

The results of this survey among dental practitioners indicate important knowledge gaps regarding the orthodontic management of teeth affected by a traumatic insult. Since this situation is not uncommon in clinical practice, the topic requires more attention in undergraduate training, specialist training and continuing education. In addition, the development of evidence-based guidelines would be very helpful for dental practitioners, both for the management of those cases but also for informing patients and parents properly.

Why this paper is important for paediatric dentists

- A correct diagnosing of adverse events after a traumatic dental injury can prevent further complications when traumatized teeth need an orthodontic approach.

- The various understanding of these adverse events should encourage paediatric dentists and other disciplines in dentistry to improve their knowledge by additional training.

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Tables

TABLE 1 Orthodontic treatment recommendation and expected adverse reactions in case of orthodontic treatment of a tooth showing ankylosis after traumatic injury

	General dentists N = 121	Paediatric dentists N = 47	Orthodontists N = 99	P-value
Treatment recommendation	n = 112	n = 46	n = 96	
no, certainly not	11 (9.8%)	11 (24.0%)	1 (1.1%)	< 0.001*
rather not	48 (42.9%)	13 (28.3%)	11 (11.5%)	
maybe	35 (31.3%)	12 (26.1%)	19 (19.8%)	
probably	17 (15.2%)	7 (15.2%)	44 (45.8%)	
yes, certainly	1 (0.9%)	3 (6.5%)	21 (21.9%)	
Adverse reactions				
apical pathology	n = 93	n = 37	n = 64	
yes	34 (36.6%)	6 (16.2%)	13 (20.3%)	0.035*
no	37 (39.8%)	22 (59.5%)	39 (60.9%)	
no idea	22 (23.6%)	9 (24.3%)	12 (19.8%)	
tooth discoloration	n = 88	n = 38	n = 67	
yes	22 (25.0%)	4 (10.5%)	14 (20.9%)	0.471
no	49 (55.7%)	26 (68.4%)	41 (61.2%)	
no idea	17 (19.3%)	8 (21.1%)	12 (17.9%)	
external cervical resorption	n = 96	n = 41	n = 72	
yes	67 (69.8%)	27 (65.8%)	36 (50.0%)	0.026*
no	10 (10.4%)	9 (22.0%)	20 (27.8%)	
no idea	19 (19.8%)	5 (12.2%)	16 (22.2%)	
apical root resorption	n = 97	n = 40	n = 68	
yes	65 (67.0%)	25 (62.5%)	31 (45.6%)	0.019*
no	15 (15.5%)	11 (27.5%)	25 (36.8%)	
no idea	17 (17.5%)	4 (10.0%)	12 (17.6%)	
inflammatory root resorption	n = 86	n = 39	n = 69	

yes	29 (33.8%)	15 (38.5%)	17 (24.6%)	0.249
no	31 (36.0%)	16 (41.0%)	36 (52.2%)	
no idea	26 (30.2%)	8 (20.5%)	16 (23.2%)	
no movement of affected tooth	n = 105	n = 46	n = 93	
yes	87 (82.8%)	44 (95.7%)	93 (100.0%)	0.001*
no	3 (2.9%)	2 (4.3%)	0 (0.0%)	
no idea	15 (14.3%)	0 (0.0%)	0 (0.0%)	
no complications	n = 73	n = 29	n = 47	
yes	4 (5.5%)	4 (13.8%)	2 (4.3%)	0.303
no	49 (67.1%)	19 (65.5%)	37 (78.7%)	
no idea	20 (27.4%)	6 (20.7%)	8 (17.0%)	

Notes: (N = number of participants; n = number of respondents; % = percentage).

It was considered significant if $P < 0.05^*$.

TABLE 2 Orthodontic treatment recommendation and expected adverse reactions in case of orthodontic treatment of a tooth presenting apical root resorption after traumatic injury

	General dentists N = 121	Paediatric dentists N = 47	Orthodontists N = 99	P-value
Treatment recommendation	n = 107	n = 45	n = 98	
no, certainly not	8 (7.5%)	4 (8.9%)	1 (1.0%)	< 0.001*
rather not	35 (32.7%)	4 (8.9%)	17 (17.3%)	
maybe	41 (38.3%)	23 (51.1%)	14 (14.3%)	
probably	22 (20.6%)	11 (24.4%)	47 (48.0%)	
yes, certainly	1 (0.9%)	3 (6.7%)	19 (19.4%)	
Adverse reactions				
pulp necrosis	n = 94	n = 41	n = 86	
yes	65 (69.1%)	26 (63.4%)	64 (74.4%)	0.576
no	17 (18.1%)	11 (26.8%)	13 (15.1%)	
no idea	12 (12.8%)	4 (9.8%)	9 (10.5%)	
apical pathology	n = 88	n = 42	n = 84	
yes	60 (68.2%)	33 (78.6%)	57 (67.8%)	0.572
no	17 (19.3%)	7 (16.6%)	15 (17.9%)	

no idea	11 (12.5%)	2 (4.8%)	12 (14.3%)	
root canal obliteration	n = 81	n = 40	n = 76	
yes	42 (51.9%)	23 (57.5%)	59 (77.6%)	0.001*
no	21 (25.9%)	13 (32.5%)	5 (6.6%)	
no idea	18 (22.2%)	4 (10.0%)	12 (15.8%)	
tooth discoloration	n = 88	n = 40	n = 84	
yes	61 (69.3%)	22 (55.0%)	66 (78.6%)	0.028*
no	15 (17.0%)	14 (35.0%)	10 (11.9%)	
no idea	12 (13.6%)	4 (10.0%)	8 (9.5%)	
external cervical resorption	n = 82	n = 40	n = 75	
yes	42 (51.2%)	26 (65.0%)	44 (58.7%)	0.256
no	17 (20.7%)	10 (25.0%)	15 (20.0%)	
no idea	23 (28.0%)	4 (10.0%)	16 (21.3%)	
apical root resorption	n = 90	n = 42	n = 89	
yes	71 (78.9%)	36 (85.7%)	79 (88.8%)	0.265
no	10 (11.1%)	4 (9.5%)	3 (3.4%)	
no idea	9 (10.0%)	2 (4.8%)	7 (7.9%)	
inflammatory root resorption	n = 80	n = 39	n = 69	
yes	35 (43.8%)	28 (71.8%)	43 (62.3%)	0.022*
no	25 (31.2%)	7 (17.9%)	11 (15.9%)	
no idea	20 (25.0%)	4 (10.3%)	15 (21.7%)	
no movement of affected tooth	n = 80	n = 37	n = 68	
yes	9 (11.3%)	5 (13.5%)	23 (33.8%)	0.002*
no	54 (67.5%)	29 (78.4%)	32 (47.1%)	
no idea	17 (21.2%)	3 (8.1%)	13 (19.1%)	
no complications	n = 60	n = 29	n = 49	
yes	8 (13.3%)	2 (6.9%)	11 (22.4%)	0.149
no	33 (55.0%)	22 (75.9%)	25 (51.0%)	
no idea	19 (31.7%)	5 (17.2%)	13 (26.5%)	

Notes: (N = number of participants; n = number of respondents; % = percentage).

It was considered significant if $P < 0.05^*$.

TABLE 3: Orthodontic treatment recommendation and expected adverse reactions in case of orthodontic treatment of a tooth presenting pulp and root canal obliteration after traumatic injury

	General dentists N = 121	Paediatric dentists N = 47	Orthodontists N = 99	P-value
Treatment recommendation	n = 102	n = 47	n = 93	
no, certainly not	1 (1.0%)	2 (4.3%)	0 (0.0%)	< 0.001*
rather not	19 (18.6%)	3 (6.4%)	6 (6.5%)	
maybe	30 (29.4%)	19 (40.4%)	16 (17.2%)	
probably	47 (46.1%)	19 (40.4%)	49 (52.7%)	
yes, certainly	5 (4.9%)	4 (8.5%)	22 (23.6%)	
Adverse reactions				
pulp necrosis	n = 91	n = 40	n = 78	
yes	52 (57.1%)	21 (52.5%)	46 (59.0%)	0.731

no	29 (31.9%)	16 (40.0%)	22 (28.2%)	
no idea	10 (11.0%)	3 (7.5%)	10 (12.8%)	
apical pathology	n = 91	n = 41	n = 75	
yes	47 (51.6%)	23 (56.1%)	45 (60.0%)	0.785
no	34 (37.4%)	14 (34.1%)	21 (28.0%)	
no idea	10 (11.0%)	4 (9.8%)	9 (12.0%)	
tooth discoloration	n = 89	n = 42	n = 83	
yes	57 (64.1%)	24 (57.1%)	65 (78.3%)	0.055
no	23 (25.8%)	15 (35.7%)	11 (13.3%)	
no idea	9 (10.1%)	3 (7.2%)	7 (8.4%)	
external cervical resorption	n = 86	n = 42	n = 76	
yes	32 (37.2%)	20 (47.6%)	37 (48.7%)	0.227
no	33 (38.4%)	18 (42.9%)	24 (31.6%)	
no idea	21 (24.4%)	4 (9.5%)	15 (19.7%)	
apical root resorption	n = 88	n = 44	n = 80	
yes	51 (57.9%)	25 (56.8%)	55 (68.7%)	0.283
no	21 (23.9%)	14 (31.8%)	18 (22.5%)	
no idea	16 (18.2%)	5 (11.4%)	7 (8.8%)	
inflammatory root resorption	n = 86	n = 43	n = 70	
yes	21 (24.4%)	20 (46.5%)	27 (38.6%)	0.125
no	44 (51.2%)	16 (37.2%)	30 (42.8%)	
no idea	21 (24.4%)	7 (16.3%)	13 (18.6%)	
no movement of affected tooth	n = 87	n = 41	n = 74	
yes	17 (19.5%)	3 (7.3%)	22 (29.7%)	0.012*
no	54 (62.1%)	35 (85.4%)	40 (54.1%)	
no idea	16 (18.4%)	3 (7.3%)	12 (16.2%)	
no complications	n = 59	n = 31	n = 49	
yes	11 (18.6%)	3 (9.7%)	19 (38.8%)	0.002*
no	25 (42.4%)	22 (71.0%)	22 (44.9%)	
no idea	23 (39.0%)	6 (19.3%)	8 (16.3%)	

Notes: (N = number of participants; n = number of respondents; % = percentage).

It was considered significant if $P < 0.05^*$.

Accepted Article

Figures

Figure 1: Tooth ankylosis after re-implantation of an avulsed upper incisor

Figure 2: Apical root resorption after uncomplicated crown fracture of a central upper incisor

Figure 3: Pulp root canal obliteration of a central upper incisor after lateral luxation injury

Figure legends

Fig. 1, case 1. A girl, 8 years old, (healthy, no documented allergies) experienced a dental trauma when hitting the floor during a fall at school. This resulted in avulsion of tooth 21. The tooth was preserved in (tap)water and repositioned within one hour. The patient was referred six weeks after the reimplantation of tooth 21 (a). The tooth was treated endodontically by means of MTA apexification. Check-up 6,5 years after the original trauma, shows ankylosis of tooth 21 (b,c,d).

Fig. 2, case 2. A boy, 10 years old, (healthy, no documented allergies) fell on a playground with extrusive luxation of tooth 21 and enamel/dentin fracture (without pulp exposure) of tooth 11 as a result (a, b). Tooth 21 was repositioned, splinted for 2 weeks and an endodontic treatment was performed (MTA apexification); tooth 11 was restored using composite material. The patient was treated orthodontically and was seen 5 years later for follow-up. At that moment, tooth 11 showed signs of apical root resorption (c,d).

Fig. 3, case 3. A girl, 7.5 years old, (healthy, no recorded allergies) bumped with her teeth into another child's head while jumping on a trampoline. As a result, tooth 11 was displaced in palatal direction. The tooth was not repositioned (a) but moved spontaneously into its original position within a few days. The tooth was followed-up over several years; no endodontic treatment was carried out. After 3.5 years there are no signs of pulp necrosis, there is apical closure and obliteration of the pulp and root canal (b, c).