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Crown and crown–root fractures: an evaluation of the treatment plans for management proposed by 154 specialists in restorative dentistry

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Abstract – Traumatic tooth injuries involve function and aesthetics and cause damage that range from minimal enamel loss to complex fractures involving the pulp tissue and even loss of the tooth crown. Technical knowledge and clinical experience are essential to establish an accurate diagnosis and provide a rational treatment. The purpose of this study was to evaluate the knowledge of Restorative Dentistry specialists about the management of crown and crown–root fractures based on treatment plans proposed by these professionals for these cases. A descriptive questionnaire was mailed to 245 Restorative Dentistry specialists with questions referring to their professional profile and the treatment plans they would propose for the management of crown and crow-root fractures resulting from dental trauma. One hundred and fifty-four questionnaires were returned properly filled. The data were subjected to descriptive statistics and the chi-square test was used to determine the frequency and the level of the significance among the variables. The analysis of data showed that in spite of having a specialist title, all interviewees had great difficulty in planning the treatments. As much as 42.8% of the participants were unable to treat all types of dental trauma. Complicated and uncomplicated crown–root fractures posed the greatest difficulties for the dentists to establish adequate treatment plans because these fractures require multidisciplinary knowledge and approach for a correct case planning and prognosis.

The integrity of teeth and periodontal tissues is directly related to the maintenance of the health of the involved structures, which may be damaged by oral diseases or trauma (1). Traumatic tooth injuries have progressively gained epidemiological expression as an emergent public health problem (2, 3) because of caries incidence decline owing to the advances in preventive dentistry (3–5), the high incidence of physical violence and traffic accidents and the increased popularity of radical and contact sports (5).

Teeth and supporting tissues can be traumatized in different manners, the main causes being collision, epilepsy, sports activities, physical assault, working accidents, car, motorcycle and bicycle accidents, and falls. These accidents represent an emergency situation in which the patient should be evaluated by a dentist (6, 7). Most cases of dental trauma involve the anterior region of the mouth, affecting mainly the maxillary central incisors while the mandibular incisors are the least frequently traumatized teeth (7–11). Some patients present multiples fractures and repeated traumatic injuries, with incidence ranging from 4% to 24% (12).

Crown and crown–root fractures involve change from enamel, dentin, cementum, pulp to enamel, dentin, pulp, cementum, needing an interdisciplinary approach to be properly treated (13, 14). This multidisciplinarity is characteristic of the formation of general dentists (15).

The healing pattern that occurs after dental trauma is related to the type of the tissue involved as well as the severity of the trauma and the stage of root development at the moment of trauma (12). Other factors that can be controlled by the dentist, such as the type of treatment and the time elapsed since the trauma, should also be considered. Therefore, the greater the knowledge of dental traumatology and interdisciplinary management of trauma cases, the greater the possibility of success (3).

The purpose of this study was to evaluate the knowledge of Restorative Dentistry specialists about the management of crown and crown–root fractures

based on treatment plans proposed by these professionals for these cases.

Materials and methods

The research project was reviewed and approved by the Research Ethics Committee of the Araçatuba Dental School of the Sate University of São Paulo, Brazil.

A 9-item self-applied questionnaire was developed for the study. Two hundred and forty-five questionnaires were mailed to dentists that completed the Specialization Course in Restorative Dentistry at the Araçatuba Dental School, São Paulo State University, Brazil, between 1984 and 2006. The questions referred to two parts; (A) the professional profile and (B) the treatment plans. (A) The professional profile contains year of graduation, dental school they graduated from, age, area of expertise, specialization course apart from Restorative Dentistry; (B) in the treatment plans they would propose for the management of crown and crow-root fractures resulting from dental trauma according to Fig. 1. Only questionnaires that were returned properly filled were considered to compose the non-probabilistic sample.

Andreasen's (1974) classification based on the classification proposed by the World Health Organization (1969) was used in order to group the treatment plans proposed by the interviewees: enamel crack, enamel fracture, enamel/dentin fracture, complicated enamel/dentin fracture with pulp exposure, uncomplicated crown–root fracture without pulp exposure and complicated crown–root fracture with pulp exposure (Fig. 1).

The data collected for the study remained confidential and were used for insurance of the quality and to form the curriculum for postgraduate education. All participants were volunteers and had their identity preserved. The treatment plans proposed by the interviewees were classified as adequate or inadequate, based on research-based data published in the international literature (1, 7, 11, 13–34).

After collecting all questionnaires, the data were subjected to statistical analysis using EPI-INFO 3.3 software (Centers for Disease Control and Prevention, Atlanta, GA, USA). The descriptive statistics included the analysis of the distribution of frequencies for the questions posed to the participants. Associations among the variables were verified with the chi-square test at 5% significance level ($\alpha = 0.05$).

Results

Professional profiles

From the 245 questionnaires sent to the eligible volunteers, only 154 (62.44%) were returned properly filled. The following data were obtained from the analysis of the responses to the questions.

Twenty-seven dentists had less than 5 years of graduation, 23 had 6–10 years, 52 had 11–20 years, 46 had 21–30 years, 5 had more than 30 years and 1 participant did not answer to this question. Seventy-six participants graduated from private dental schools, 77 graduated from public dental schools (67 of them graduated from the Araçatuba Dental School, São Paulo State University) and 1 participant did not answer to this question. Regarding the gender, 66 interviewees were men and 88 were women. Thirty-five dentists completed the Specialization Course in Restorative Dentistry between 1985 and 1989; 66 between 1990 and 1999 and 45 between 2000 and 2006. Eight participants did not answer to this question. Regarding the area of expertise, 19 dentists affirmed to act just as Restorative Dentistry specialists and the others act in more than one area.

Treatment plans

The treatment plans proposed by the volunteers for the management of the crown and crown–root fractures were divided in adequate and inadequate.

For enamel crack, the adequate plans proposed by the Dentistry specialists were composite resin restoration ($n = 94$), watchful waiting ($n = 37$) and composite resin restoration or watchful waiting ($n = 6$). The inadequate treatment plans were adhesive tooth fragment reattachment ($n = 5$), sealant placement ($n = 11$) and porcelain veneers ($n = 1$).

For enamel fractures, the adequate treatment plans proposed by the volunteers were composite resin restoration ($n = 100$), composite resin restoration or tooth fragment reattachment ($n = 50$) and adhesive tooth fragment reattachment ($n = 3$). Only one volunteer proposed an inadequate procedure (watchful waiting).

For enamel/dentin fractures, adequate treatment plans were the adhesive tooth fragment reattachment or composite resin restoration ($n = 126$) and composite resin restoration ($n = 12$). Inadequate treatment plans included porcelain or ceromer veneers ($n = 7$), pulpal therapy ($n = 8$) and crown lengthening surgery and prosthesis ($n = 1$).

For complicated crown fractures with pulp exposure, the adequate treatment plans proposed by the Dentistry specialists were composite resin restoration ($n = 57$), composite resin restoration or adhesive tooth fragment reattachment ($n = 58$), prosthesis ($n = 8$), adhesive tooth fragment reattachment ($n = 1$), adhesive tooth fragment reattachment ($n = 3$) and prosthesis or composite resin restoration or prosthesis ($n = 9$). Porcelain or ceromer veneers ($n = 8$), pulpal therapy ($n = 3$), surgical or orthodontic extrusion of the coronal fragment ($n = 5$) and crown lengthening surgery ($n = 2$) were inadequate treatment plans proposed for this type of fractures. The following pulpal therapies were suggested for complicated crown fractures with pulp exposure: direct pulp capping ($n = 6$), pulpotomy ($n = 5$), direct pulp capping or pulpotomy ($n = 5$), root canal treatment ($n = 54$), direct pulp capping or pulpotomy or root canal treatment ($n = 47$), pulpotomy or root canal treatment ($n = 13$), direct pulp capping or root canal treatment ($n = 6$). Regarding the restorative treatments, 28 participants indicated glass fiber posts, 7 indicated carbon glass posts and 2 participants indicated either one type of post.

Treatment plans proposed for uncomplicated crown–root fractures without pulp exposure were composite resin restoration ($n = 34$), prosthesis ($n = 43$), composite resin restoration or prosthesis ($n = 10$), composite

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QUESTIONNAIRE

(A) Professional profiles

1. Please inform your year of graduation from dental school.....
2. What dental school you graduated from? .....
3. Please inform your age .....
4. Gender: ( ) Female ( ) Male
5. When did you complete your Specialization course in Restorative Dentistry? .....
6. In addition to Restorative Dentistry, do you have expertise in other dental areas? Yes ( ) No ( )
7. Which one(s)? (only for those who answered "Yes" to question 6) ( ) Endodontics ( ) Prosthodontics ( ) Periodontics ( ) Pediatric Dentistry ( ) Surgery ( ) Orthodontics

(B) Treatment plans

8. In order to facilitate the treatment of root-crown fractures, a classification was proposed by Andreasen (1974) based on the classification proposed by the World Health Organization in 1969 for both primary and permanent dentitions. Considering this classification, presented in table below, please mark which treatment plan would you indicate for each type of dental trauma.

Scheme	Classification	Type of treatment	
	Enamel crack	1. Adhesive tooth fragment reattachment 2. Composite resin restoration 3. Porcelain or ceromer veneer 4. Direct pulp capping 5. Pulpotomy 6. Root canal therapy 7. Intraradicular glass fiber post	8. Intraradicular carbon fiber post 9. Prosthesis 10. Surgical extrusion 11. Orthodontic extrusion 12. Crown lengthening surgery 13. Gingivectomy/gingivoplasty 14. Others. Specify:_____
	Enamel fracture	1. Adhesive tooth fragment reattachment 2. Composite resin restoration 3. Porcelain or ceromer veneer 4. Direct pulp capping 5. Pulpotomy 6. Root canal therapy 7. Intraradicular glass fiber post	8. Intraradicular carbon fiber post 9. Prosthesis 10. Surgical extrusion 11. Orthodontic extrusion 12. Crown lengthening surgery 13. Gingivectomy/gingivoplasty 14. Others. Specify:_____
	Enamel/dentin fracture	1. Adhesive tooth fragment reattachment 2. Composite resin restoration 3. Porcelain or ceromer veneer 4. Direct pulp capping 5. Pulpotomy 6. Root canal therapy 7. Intraradicular glass fiber post	8. Intraradicular carbon fiber post 9. Prosthesis 10. Surgical extrusion 11. Orthodontic extrusion 12. Crown lengthening surgery 13. Gingivectomy/gingivoplasty 14. Others. Specify:_____
	Complicated enamel/dentin fracture (with pulp exposure)	1. Adhesive tooth fragment reattachment 2. Composite resin restoration 3. Porcelain or ceromer veneer 4. Direct pulp capping 5. Pulpotomy 6. Root canal therapy 7. Intraradicular glass fiber post	8. Intraradicular carbon fiber post 9. Prosthesis 10. Surgical extrusion 11. Orthodontic extrusion 12. Crown lengthening surgery 13. Gingivectomy/gingivoplasty 14. Others. Specify:_____
	Crown-root fracture	1. Adhesive tooth fragment reattachment 2. Composite resin restoration 3. Porcelain or ceromer veneer 4. Direct pulp capping 5. Pulpotomy 6. Root canal therapy 7. Intraradicular glass fiber post	8. Intraradicular carbon fiber post 9. Prosthesis 10. Surgical extrusion 11. Orthodontic extrusion 12. Crown lengthening surgery 13. Gingivectomy/gingivoplasty 14. Others. Specify:_____
	Complicated crown-root fracture (with pulp exposure)	1. Adhesive tooth fragment reattachment 2. Composite resin restoration 3. Porcelain or ceromer veneer 4. Direct pulp capping 5. Pulpotomy 6. Root canal therapy 7. Intraradicular glass fiber post	8. Intraradicular carbon fiber post 9. Prosthesis 10. Surgical extrusion 11. Orthodontic extrusion 12. Crown lengthening surgery 13. Gingivectomy/gingivoplasty 14. Others. Specify:_____

9. Would you be able to treat all types of dental trauma presented in table above? ( ) Yes ( ) No. Justify your answer.

Fig. 1. Self-applied questionnaire was developed for the study.

resin restoration or tooth fragment reattachment ($n = 8$) and adhesive tooth fragment reattachment ($n = 1$). For reestablishment of the biological width, the treatment plans included: orthodontic extrusion of the coronal fragment or crown lengthening surgery ($n = 28$), orthodontic extrusion of the coronal fragment ($n = 33$), orthodontic/surgical extrusion of the coronal fragment ($n = 1$), crown lengthening surgery ($n = 31$), restorative alveolar interface (RAI) ($n = 2$) and orthodontic/surgical extrusion of the coronal fragment or crown lengthening surgery ($n = 1$). Inadequate treatment plans for uncomplicated crown–root fractures without pulp exposure were orthodontic/surgical extrusion of the coronal fragment ($n = 21$), root canal therapy and crown lengthening surgery ($n = 3$), pulpotomy ($n = 4$), extraction ($n = 6$), direct pulp capping ($n = 2$), tooth restoration without reestablishing the biological width ($n = 18$), ceromer veneers ($n = 3$) and postcementation without root canal therapy ($n = 1$).

For complicated crown–root fractures with pulp exposure, the adequate treatment plans proposed by the volunteers were composite resin restoration ($n = 4$), composite resin restoration or prosthesis ($n = 26$), prosthesis ($n = 52$) and composite resin restoration or adhesive tooth fragment reattachment ($n = 1$). All 83 restorative procedures considered as adequate included pulpectomy and root canal treatment. Extraction ($n = 23$), orthodontic/surgical extrusion of the coronal fragment and adhesive tooth fragment reattachment ($n = 12$), pulpotomy ($n = 16$), tooth restoration without reestablishing the biological width ($n = 19$) and postcementation without root canal therapy ($n = 1$) were considered as inadequate for the treatment of complicated crown–root fractures with pulp exposure.

Regarding the question 9 of the questionnaire, 66 dentists judged themselves unable to treat all types of dental trauma, whereas 88 believed that they would treat any dental trauma case properly.

Table 1. Proportion test considering the treatment plans for each type of injury

Traumatic injuries	Treatment plan			
	Inadequate	Adequate	%	*P*
Enamel crack	17	137	88.96	a
Enamel fracture	1	153	99.35	a
Enamel/dentin fracture	16	138	89.61	a
Complicated enamel/dentin fracture	18	136	88.31	a
Uncomplicated crown-root fracture	58	96	62.34	b
Complicated crown- root fracture	71	83	53.90	b

Different letters indicate statistically significant difference among the treatment plans proposed by the interviewed Dentistry specialists ($P < 0.05$). Groups represented by'' a'' and '' a'' are similar, and ''a'' and''b'' are different from the statistical point of view.

Among the treatment plans classified as inadequate, the statistical analysis showed an association between the traumatic injuries and the number of years since graduation, with a high incidence of inadequate treatment plans among professionals with less than 5 years of graduation. The differences were statistically significant ($P < 0.001$) for enamel crack, enamel/dentin fractures and complicated enamel/dentin fractures. There were no statistically significant differences ($P > 0.05$) among dentists graduated from private and public schools. The statistical analysis showed significant differences ($P < 0.05$) among the treatment plans proposed for the different types of traumatic tooth injuries (Table 1).

Discussion

Traumatic tooth injuries involve function and aesthetics and cause damage that may range from minimal enamel loss to complex fractures involving the pulp tissue and even loss of the tooth crown. The institution of a rational therapy needs the establishment of an accurate diagnosis (35). In addition to causing damage to the dental hard tissues and the pulp, traumatic tooth injuries may involve the supporting periodontal structures, leading to a completely different prognosis (36–38). Several questions persist about the treatment of crown and crown–root fractures (7).

Although the incidence of dental trauma has reached epidemiological levels in recent years (2, 4, 5), the management of crown–root fractures with sound knowledge is considered a rare occurrence among dentists. The treatment itself and the functional and aesthetic recovery are challenging in most cases and the dentist should be well prepared and updated to provide the best care possible and, whenever possible, reestablish the original form of the teeth without producing additional damage (8).

In the present study, although the interviewees were dental professionals with expertise in aesthetics, the results were disappointing as 42.8% of them judged themselves unable to perform all types of treatment proposed. Among those who affirmed to be able to treat properly fracture cases, 47.2% recognized the need for specialized professional help for orthodontic or periodontal procedures, characterizing the importance for a multidisciplinary knowledge in the management of trauma cases (15).

A similar study investigating the knowledge of Brazilian general dentists and endodontists about the emergency management of dentoalveolar trauma cases (39) revealed poor knowledge of dental trauma management among the surveyed dentists and highlights the need to develop strategies to improve the knowledge base in this area of dentistry for the benefit of the dental trauma patient.

Restorative Dentistry specialists work directly with the recovery of aesthetics and have technical knowledge for offering satisfactory restorative treatments to their patients. However, the resolution of some traumatic tooth injuries extends the limit of their specialty and requires knowledge of all aspects involved in the trauma to be managed in a logical manner and preserve tooth vitality, function and aesthetics. This reality makes clear the importance of having dental trauma knowledge spread among dental professionals, namely dentists and auxiliary personnel (40). Regarding the knowledge acquired during graduation, there were no significant differences among dentists graduated from private and public schools in the present study.

The clinical experience, sedimentation of basic knowledge and the continuous updating are essential for treatment success in all specialties. The lack of experience may justify the significant difference observed among dentists with less than 5 years of graduation regarding the recommendation of inadequate procedures for treatment enamel crack, enamel/dentin fractures and complicated enamel/dentin fractures.

Enamel crack are the most common type of tooth fracture, but are frequently overlooked in clinical practice. They appear as fissures within the enamel structure that do not extend beyond the dentinoenamel junction (41). In the present study, only 37 professionals opted for the watchful waiting approach for enamel crack, whereas 94 professionals restored the teeth, probably in order to strengthen the dental structure.

Among the crown fractures, those involving only enamel are the easiest to be restored. In these cases, the best option for minor enamel fractures is enamel plasty with rounding and polishing of the incisal edges. In some cases, depending on their extension, enamel fractures can be restored with composite resin (16). This treatment was proposed by 150 professionals of whom 53 indicated adhesive tooth fragment reattachment depending on the fragment size and adaptation to the remaining croon portion. Dentin fractures should be restored by eliminating the possibility of pulpal irritation in order to have a better prognosis (16, 17). In these cases, the patient is emotionally distressed and so positive emotional effects result from fragment bonding and increase the patient's self-esteem. Therefore, this type of procedure was the first choice in the 126 treatment plans proposed for enamel/dentin fractures without pulp exposure. Teeth restored with adhesive tooth fragment reattachment offer advantages, such as shorter treatment duration, preservation of sound dental structure, restoration with similar contouring as that of the natural tooth and better aesthetics since shade match and translucency will match

and the enamel colour, brightness and texture are preserved. In addition, the incisal edge will wear at a rate similar to that of the adjacent teeth, while composite restorations wear faster than natural teeth (18–25). Tooth fragment reattachment is more economical and the replacement of the fractured portion may be less time consuming than composite resin reconstruction (24, 42).

However, factors such as pulp exposure and periodontal integrity will guide the treatment approach. In case of pulp exposure, the authors are unanimous in indicating procedures to preserve pulp vitality (26–29, 42–44). However, in the present study, 120 interviewees indicated pulpectomy as the pulpal therapy of choice, although 66 of them also considered the possibility of performing a conservative treatment (direct pulp capping and/or pulpotomy). Sixty-two professionals indicated adhesive tooth fragment reattachment, which is in accordance with the literature (30, 45, 46). Direct pulp capping may also be indicated after trauma. Calcium hydroxide is the material of choice because it eliminates the contamination of the exposed dentin and pulp tissue and stimulates the formation of a hard tissue barrier (31). However, although simpler procedures, like tooth fragment reattachment and composite resin restorations, were more frequently indicated, more complex treatment plans involving root canal therapy, postcementation and prosthetic restorations were proposed by several professionals, which could weaken the fractured tooth, especially in young patients with immature teeth. Perhaps, these procedures were indicated because of the lack of knowledge or confidence in new materials and techniques.

The analysis of data showed that, as expected, uncomplicated and complicated crown–root fractures were the most difficult types of fracture to be management, with significant difference among the treatments proposed by the professionals, probably because they are related to the invasion and recovery of the periodontal biological width. The techniques for recovery of the biological width should consider the junctional epithelium as the most vulnerable point for the penetration of bacteria into the connective tissue. Therefore, under normal conditions, 2–3 mm of sound dental structure should be preserved between the alveolar crest and the restoration margin (47). This distance was reestablished in two cases using the RAI procedure, which is a technique for the modification of the interproximal area that could create ideal conditions for the restoration of the tooth structure and maintenance of periodontal health. In this technique, a full-thickness flap is raised to expose the interproximal root surface and the alveolar bone crest, the cervical bevel of the fracture is eliminated by polishing the root surface and a more coronal margin is established at a distance from the bone level within the biological requirements (47). In more complex cases in which the cervical bevel did not permit root planning, procedures for reestablishment of the biological width, such as crown lengthening surgery or orthodontic extrusion, were proposed by 96 professionals. According to Baratieri et al. (32, 33), crown lengthening surgery is the most indicated procedure for reestablishment of the biological width in cases of tooth fractures close to the alveolar bone crest, but the authors state that, in spite of its efficiency, this technique is difficult to be applied in anterior teeth because the aesthetics can be compromised. The reestablishment of the biological width is of paramount importance and surgical/orthodontic extrusion is one of the procedures indicated for this purpose (34). However, a critical analysis should be performed when the treatment choice is adhesive tooth fragment reattachment because it may alter the incisal and occlusal line and provide a poor result. In the present study, 21 volunteers proposed adhesive tooth fragment reattachment for management of uncomplicated crown–root fractures. When a great amount of tooth remnant is left after fracture, more conservative restorative procedures can be performed. Although, 11 interviewees indicated the cementation of posts, perhaps to increase the retention or reinforce the dental structure in the restorative procedures.

Complicated crown–root fractures with pulp exposure followed the same techniques for reestablishment of the biological width in 83 treatment plans proposed by the volunteers. After reestablishment of the biological width, the restorative treatment was indicated according to the amount of remaining dental structure. The cementation of aesthetic posts in the root canal permits the construction of direct cores, which facilitates tooth restoration. Another possibility suggested by 78 professionals was the fabrication of single crowns, reestablishing function and aesthetics (48, 49).

The restorative treatment of traumatized teeth should respect the dental and periodontal structures involved and the dentist should be able to indicate effective therapeutic measures that provide the best possible prognosis. However, factors such as the severity of trauma, stage of root formation, time elapsed since the trauma and adverse issues regarding the application of the techniques will influence the treatment success (3, 25).

Therefore, the basic biological and technical concepts, the improvement of restorative techniques and the adoption of an interdisciplinary approach are essential for a proper management of dental trauma. Nevertheless, in spite of having knowledge, dentists usually have trouble making a correct diagnosis and establishing an effective treatment plan. It is clear that although the theoretical concepts are quite spread, the fact that dental traumas are not routinely seen in everyday practise makes their management naturally challenging and pose difficult for elaboration of treatment plans, deserving more attention.

Conclusion

Complicated and uncomplicated crown–root fractures posed the greatest difficulties for the dentists to establish adequate treatment plans because these fractures require multidisciplinary knowledge and approach for a correct case planning and prognosis.

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