Dental Traumatology 2004; 20: 314–326

DENTAL TRAUMATOLOGY

Federal University of Santa Catarina endodontic treatment of traumatized primary teeth – part 2

Rocha MJC, Cardoso M. Federal University of Santa Catarina endodontic treatment of traumatized primary teeth – part 2. Dent Traumatol 2004; 20: 314–326. © Blackwell Munksgaard, 2004.

Maria José de Carvalho Rocha, Mariane Cardoso

Pediatric Dentistry Department, Federal University of Santa Catarina, Florianópolis, Santa Catarina, Brazil

Abstract – This research sought to evaluate periapical repair in 28 traumatized deciduous teeth that had suffered endodontic intervention due to the presence of internal or external inflammatory resorption or replacement root resorption. After obtaining endodontic access, work length and biomechanical preparation, the root canals were filled with calcium hydroxide and propylene glycol under the form of a dense slurry, during 12 months. Replacement of the intracanal dressing was performed when monthly radiographic examinations showed its absence. After 12 months the teeth were obturated with zinc oxide and eugenol cement. Halting of the inflammatory and replacement root resorption (64.3%; $n = 28$) occurred 9 months after the use of calcium hydroxide dressings, in a total of 18 successful cases. Fisher's test was applied to relate success with the type of trauma, work length time, child's age and pulpal condition. The test did not present statistical significance ($P < 0.05$). However, in the qualitative analysis, failure was observed in those cases (35.7%) where replacement resorption was already present at the moment of treatment (up to two-thirds) associated with severe trauma cases. The authors concluded that endodontic treatment must be initiated at an early stage, and must be coincident with the radiographic signs of resorption. Success of the treatment is directly related to the seriousness of the sequelae at the moment of the first examination or the endodontic treatment.

Key words: trauma; primary dentition; endodontic treatment

Mariane Cardoso DDS, Rua Pastor Willian Richard Schisler Filho, 980 apto 204, Itacorubi, 88034-100, Florianópolis, Santa Catarina, Brazil
Tel./fax: 55 48 333 1527
e-mail: mariane_cardoso@hotmail.com (or) marianecardoso@bol.com.br

Accepted 10 December, 2003

Upper anterior deciduous teeth are the most affected by traumatisms (1–4) at a still very precocious age (3, 5, 6). When these teeth are lost in the beginning or even in the middle of their biologic cycle, esthetic alterations are introduced, with a reduction of the child's self-esteem, making speech difficult or even contributing to install deleterious habits (7). Sequelae brought about by the trauma can install at short, medium or long-term on deciduous teeth and also on permanent successors.

According to how serious the trauma is, we might have a color alteration of the crown, obliteration of the root canal, pulp necrosis and replacement and inflammatory (internal or external) root resorption (8).

Consequences of trauma upon the deciduous tooth are similar to those on the permanent tooth, involving the same structures in one same tissue environment. Thus, therapeutic maneuvers similar to those used for permanent teeth can be applied to deciduous ones.

The temporary condition of the deciduous tooth does not justify conducting precarious treatments (9) where biologic principles are overlooked or neglected. The other factor that must not inhibit the therapeutic treatment of a deciduous tooth is the presence of the permanent successor. As a rule, aggressions to the permanent tooth are a consequence of physical or biologic trauma, when the inflammatory reaction is perpetuated by maintaining necrotic pulp tissue in the root canal, either infected or not. However, the treatment of traumatized deciduous teeth has to be conducted according to a triangular professional–child–responsible person relationship, which is inserted in an integral treatment plan (4, 10). Family involvement becomes essential in overcoming behavioral barriers placed by the child and those nutritional habits inherent to a child's world. Such habits might compromise evolution of follow-up and treatment of the traumatized tooth.

To institute protocols for the longitudinal follow-up of traumatized deciduous teeth, having in mind an early endodontic intervention when necessary, may contribute to maintain the teeth during all their biologic cycle. Based on that hypothesis, a new protocol was created in 1998 for the treatment of children who have a traumatized deciduous tooth (Routine 1). Thus, the goal of the present research was to interrelate the patient's age, kind of trauma, time elapsed from trauma to endodontic intervention, kind of pretreatment sequelae, pulp condition diagnosis, and time elapsed for the determination of the root work length (RWL) filling, to find the possible causes related with success or failure of treatment conducted as per Federal University of Santa Catarina (UFSC) Protocol for traumatized deciduous teeth (Routine 1), so as to ratify or alter the performed clinical procedures (Routine 2).

Methodology

Patients who had traumatized teeth, and presented themselves at the Pediatric Dental Clinic of the Federal University of Santa Catarina Brazil, received assistance as per the UFSC Protocol for the treatment of traumatized deciduous teeth, previously established by the Pediatric Dental Clinic of that university.

It should be noted this protocol, after August 1998, has been performed by only one professional, and all the 28 traumatized teeth (24 children) included in this study were seen by the clinicians. Treatment was started with questions, including personal data, history of other trauma, data on existing trauma and main complaint by the patient, in addition to information on feeding habits, buccal hygiene, caries history and harmful habits. After that, the parents or responsible persons read and signed an informed consent term.

The first clinical examination was conducted obeying all the pediatric dentistry techniques and starting with the soft tissue (laceration, tumefaction and fistula), to be then followed by the dental tissue (color alterations of the crown, increased mobility, and percussion sensitivity). Cold/heat vitality tests were not made, as little credit could be given to the children's answer and, in provoking pain, possibly compromise the management of the child's behavior. Next, a radiographic examination was made (70 kV with a 0.2-s exposure) using radiographic devices (Indus Bello, Loudrina, Brazil) and either an adult or an infantile film according to patient's age (Ultra-Speed, Kodak, Rochester, NY, USA) or employing Randall's technique (11). In cases of intrusion, lateral view radiographs were made (70 kV with a 0.8-s exposure) (12) in association with the radiographic examination. Following the above-described stages, a diagnosis was made of the traumatized teeth, as per Garcia-Godoy (13) modified classification.

Numerous are the children who present for examination days, months, or even years after their trauma. In such cases, an association was made between examinations, both clinical and radiographic, and the personal data, in an effort to determine a correct diagnosis for the specific trauma.

The teeth submitted to endodontic treatment exhibited different kinds of trauma: enamel and dentin fracture, coronary fracture with pulp exposure, radicular fracture, concussion, subluxation, lateral luxation, intrusion and avulsion. Table 1 shows the age distribution at the time of endodontic treatment, and also the time elapsed from trauma to beginning of endodontic intervention, pulp condition and sequelae, and time for the establishment of the RWL, all such factors related to the kind of trauma.

At the first visit, teeth presenting mobility (mild, moderate or severe) were splinted by means of a semi-rigid splint (0.8 nylon or 0.5 steel wire) attached with flow composite resin (DFL, Rio de Janeiro, Brazil). Time of splinting depended on factors such as persistence of increased mobility, kind of trauma, interference of nutritional habits, and reincidence of trauma.

Irrespective of the kind of trauma, endodontic treatment was indicated for teeth presenting one or more signs and/or symptoms of periapical bone rarefaction, presence of fistula (indicating pulp necrosis), coronary fracture with pulp exposure, replacement root resorption, and external or internal inflammatory root resorption (Figs. 1, 9, 10). The need for endodontic intervention was not indicated in cases of color alteration of the crown or obliteration of the root canal only.

Children younger than 3 years, who could not behave properly, were treated on a 'Macri' (child stretcher), having always the responsible person present. Those who behaved well, and those older than 3 years, were examined on the chair; the

Table 1. Distribution of some of the aspects associated with success or failure of the Federal University of Santa Catarina Protocol for traumatized deciduous teeth

Patients (*n*)	Age in the beginning of endodontic treatment	Type of trauma	Time elapsed between occurrence of injury and endodontic treatment	Pulp condition	Time elapsed until the RWL-UFSC technique	Clinical and radiographic evidence	Time elapsed between occurrence of injury and sequelae	Success or failure
13	4 years 10 months	CR	3 years	NV	1 month	Reduction FI (6 months)	–	s
04	2 years	CFEx	7 months	NV	N	Reduction MO and PS (2 months)	–	s
16	2 years 3 months	CFEx	3 months	NV	2 months	Decreased IRR (4 months)	–	s
18	5 years 9 months	CFEx	5 years	NV	<1 month	Decreased IRR and reduced PBR (5 months)	–	s
01	2 years 6 months	RF	1 month	V	N	Reduced MO and GI	–	s
02	3 years 7 months	RF	5 months	NV	4 months	Reduced PBR and appearing FI	13 months	f
06	4 years	RF	2 months	C	2 months	Decreased RRR (5 months)	–	s
09	3 years 2 months	C	5 months	NV	N	Decreased RRR (7 months)	–	s
11	2 years 11 months	C	9 months	NV	5 months	Increased RRR (1/3 to 2/3 + FI)	5 months and 12 months	f
19	3 years 7 months	C	24 months	NV	1 month	Decreased RRR (9 months)	–	s
19	3 years 7 months	C	24 months	NV	1 month	Decreased RRR (9 months)	–	s
29	5 years 6 months	C	4 months	V	<1 month	Increased RRR (2/3 to 3/3)	10 months	f
03	4 years 8 months	S	<1 month	NV	1 month	Reduced IRR	Always	f
08	2 years 7 months	S	10 months	V	N	Decreased RRR (7 months)	–	s
12	2 years 10 months	S	7 months	NV	3 months	Increased IRR (1/3 to 2/3)	1 month	f
12	2 years 10 months	S	1 month	V	11 months	Decreased IRR and appearing FI	7 months	f
05	4 years 4 months	S	15 months	V	1 month	Decreased RRR (4 months)	–	s
10	3 years 4 months	S	3 months	NV	7 months	Increased RRR 1/3	1 month	f
15	4 years	S	6 months	V	3 months	Increased RRR (1/3 to 2/3)	11 months	f
17	4 years 1 month	S	2 months	V	1 month	Increased RRR until PD	16 months	f
26	5 years	LL	<1 month	V	1 month	Reduced PBR and decreased IRR (5 months)	–	s
28	4 years	LL	1 month	NV	<1 month	Decreased RRR (4 months)	–	s
28	4 years	LL	1 month	V	<1 month	Decreased RRR (4 months)	–	s
30	3 years 7 months	LL	7 months	NV	<1 month	Increased IRR	9 months	f
43	3 years 2 months	LL	28 months	V	6 months	Decreased IR and RRR (4 months)	–	s
27	3 years 11 months	LL	29 months	V	3 months	Reduced PBR and IRR (6 months)	–	s
14	2 years 5 months	I	8 months	NV	5 months	Decreased RRR (10 months)	–	s
25	2 years 5 months	A	<1 month	NV	N	Decreased RRR (5 months)	2 months	s

A, avulsion; C, concussion; CF, crown fracture without pulp exposure; FR; CFEx, crown fracture with pulp exposure; f, failure; FI, fistula; GI, gingival inflammation; I, intrusion; IR, internal root resorption; IRR, inflammatory root resorption; LL, lateral luxation; MO, mobility; N, no; ns, no success; NV, not-vital; PBR, periapical bone rarefaction; PS, percussion sensitivity; RF, root fractures; RRR, replacement root resorption; S, subluxation; s, success; V, vital.

presence of the responsible person being negotiated whenever necessary (children older than 3 years).

All the patients were anesthetized, and the tooth to be treated was usually isolated in a relative manner by means of cotton rolls and mouth-openers of the rubber-mattress (Abritec, Inodon, Porto Alegre, Brazil) or Mot (Temperinox, São Paulo, Brazil) kind, with a saliva remover. Endodontic access was obtained using no. 1 or no. 2 round burs in a 45° direction to the long axis of the tooth and 1.0 mm below the cingulum (upper teeth) until reaching the pulp chamber. Using tractioning movements (from inside out), the roof of the pulp chamber was removed and the opening completed with the Endo Z bur (Dentsply Maillefer, Petrópolis, Brazil). Diagnosis of pulp tissue status was based on radiographic signs, but the final decision as to vitality/necrosis was ascertained at the moment of endodontic opening, through direct examination of the pulp tissue. When pulp tissue presented signs of bleeding, irrespective of amount or color (cyanotic red, yellowish, light red), the pulp was deemed to be vital. In such case, biopulpectomy was the indicated treatment. Whenever the pulp tissue had 'body' but was completely whitened by the break-up of the vascular-nervous bundle (usually aseptic necrosis), and also where a disordered nervous tissue was found and had a liquefied aspect (usually septic necrosis), a classification of necrosis was attributed. In such cases, pulpectomy was also the suggested treatment.

In the first visit, following endodontic opening, septic necrosis existing, the pulp chamber was emptied, rinsed with 1% sodium hypochlorite (1% NaOCl) and a formocresol dressing on one-fifth dilution (sterile cotton pellet) was placed in the entrance of the canal. The tooth was then temporarily restored with glass–ionomer cement (VidrionR, SS White, Rio de Janeiro, Brazil).

At the first biopulpectomy consultation and the second visit for the pulpectomy of necrotic teeth, the RWL was established using the UFSC technique, which implies measuring the tooth's root length on the diagnostic X-ray using a millimeter ruler. The distance is measured from the incisal edge to: (a) the radicular apex (in the absence of contact or overlapping of the germ of the permanent tooth); (b) the pathologic or physiologic root resorption at the area of greater radiopacity; (c) the imaginary line tangent to the incisal edge of the anterior permanent successors.

The RWL being a less precise measurement, we subtracted 2 mm from it and calibrated the no. 15, 21 mm FlexoFile (FF) according to the exploratory work length (EWL = RWL − 2 mm). After introducing the EWL-calibrated FF, a new X-ray was made. On this film, the tip of the instrument may be short of, coincident with, or beyond the radicular apex, the resorption, or the imaginary line tangent to the germ of the permanent tooth, corresponding to the AB segment. Accordingly, the modeling work length (MWL) shall be: MWL = EWL + AB; or MWL = EWL; or MWL = EWL − AB. There were cases when the work length could not be ascertained immediately; the EWL was then used for emptying and instrumenting the canal (Fig. 11).

With the first series of MWL-calibrated instruments, the canal was emptied and the pulp tissue removed *en bloc*, or during biomechanical preparation. Instrumentation was made using the Flexo-Files (no. 15–40), due consideration given to the caliber of the anatomical canal and the presence of infection. Biomechanical preparation was always made under rinsing and aspiration with 1% NaOCl.

Following instrumentation, the canals were dried with absorbent paper points and filled with calcium hydroxide manipulated with propylene glycol. The slurry was dense, with a large amount of calcium hydroxide aggregated to the propylene glycol. This paste was taken to the root canal with the help of a MWL-calibrated no. 30 Flexo File and/or a 1 mm MWL-calibrated spiral lentulo bur. The calcium hydroxide paste could be radiographically observed, as it has a radiopacity similar to that of the dentin (Figs. 12–14). The pulp chamber was then cleaned and the tooth temporarily sealed with restorative glass–ionomer (VidrionR, SS White®).

Once a month, for 12 months, the child returned to the pediatric dental clinic to have a control radiograph taken. When the X-ray showed calcium hydroxide in the whole root canal (particularly in the apical third), no change was performed; in the opposite situation, a new dressing was placed.

Success being confirmed 12 months later (when there was absence of periapical bone rarefaction as a result of repair of the preexisting lesion, or the lesion not reappearing after the intervention), and a reduction in the process of pathologic root resorption (inflammatory or replacement), and the canal being dry, obturation was performed. Calcium hydroxide was removed by means of MWL-calibrated Flexo Files and 1% NaOCl rinsing. A new determination of the work length was made, when necessary, to confirm the MWL; once dry, definitive obturation was made with zinc oxide and eugenol (ZOE) cement. The cement was handled to a lesser consistence and taken to the canals with a spiral lentulo and/or a no. 30 FF endodontic tool. To make sure a good quality obturation had been performed, a radiograph was taken before definitive restoration (Fig. 2). Once obturated, these teeth were radiographically followed up every 6 months, checking for absence and/or repair of the preexisting lesion, rate of resorption of the treated tooth compared with its contralateral, and ZOE cement resorption in a similar way to that of root structures (Figs. 4–6, 15–17). Upon clinical examination, attention was given to normal mobility, percussion and homeostasis of gingival tissue, in addition to buccal hygiene.

Treatment was considered to be successful when all the above-mentioned points had been fulfilled (Figs. 7–8, 18).

Results/discussion

Radical endodontic treatment (bio and necropulpectomy) represents the last therapeutic maneuver to keep a tooth in the oral cavity, preserving or recovering the health of dental or periradicular tissues. Based on that, we intervened on traumatized deciduous teeth exhibiting fistula, periapical lesion, internal and external inflammatory root resorption and replacement radicular resorption, events that may or may not be mutually associated. Color alteration of the crown is the second most frequent sequelae associated with pulp necrosis; nevertheless, this is not always true (14). In no occasion was endodontic intervention conducted based only in the presence of change in a tooth's color: other factors had to be associated with justify intervention. Similar conduct is manifested by other authors (5, 7, 15–19).

Endodontic intervention for children has been conducted during the 20th century based only on empirical treatment and ignoring most of the time those technical scientific advancements which improved endodontic therapy.

The reasons are connected to paradigms related mostly to the manner children are handled and also to the little importance given to the deciduous tooth.

In cases where endodontic treatment becomes necessary, benefits will be greater where an early diagnosis of pathologic alterations has been issued, improving the case prognosis. When follow-up, by means of radiographs, is not performed, there will be cases where the sequelae, when identified, shall already have reached an advanced state, and in spite of endodontic treatment, prognosis for that tooth will be poor or doubtful.

From associations between successful treatment results and kind of trauma, it could be seen that the latter cannot be, by itself, responsible for the former. Concussion and subluxation, in spite of being considered mild traumas, are associated with a lesser chance of successful treatment (Tables 2 and 3). The reason is that in cases of light trauma (concussion and subluxation) the parents usually look for professional help after the sequelae have reached a severe clinical stage (Tables 4 and 5), with a resulting ineffective endodontic intervention due to already installed histopathologic reactions.

Light trauma has, apparently, greater chances of success; however, it can be seen from Table 2 that five of the six cases treated for lateral luxation attained success, whereas only two from eight cases of subluxation were successfully treated. In the case of concussion, more approximate values were seen, with three successful treatments and two failures. These data suggest the existence of other factors, in addition to kind of trauma, capable of influencing treatment success, each case having then to be individually analyzed.

Table 2. Numerical and percentage distribution of traumatized deciduous teeth in relation to the kind of trauma as to success or failure of treatments performed

Type of trauma	Success	Failure	Total
CF	1 (100)	– (–)	1 (100)
CFEx	3 (100)	– (–)	3 (100)
RF	2 (66.7)	1 (33.3)	3 (100)
C	3 (60)	2 (40)	5 (100)
S	2 (25)	6 (75)	8 (100)
LL	5 (83.3)	1 (16.7)	6 (100)
I	1 (100)	– (–)	1 (100)
A	1 (100)	– (–)	1 (100)
Total	18 (64.3)	10 (35.7)	28 (100)

A, avulsion; C, concussion; CF, crown fracture without pulp exposure; CFEx, crown fracture with pulp exposure; I, intrusion; LL, lateral luxation; RF, root fracture; S, subluxation.

Table 3. Statistically analyzed associations using chi-square test and Fisher's test, and the significance (*P*)

Association	Chi-square and Fisher's test	Significance level
Success × fracture/luxation	–	0.1836
Success × crown fracture	–	0.6428
Success × crown fracture with pulp exposure	–	0.5329
Success × root fracture	–	1.000
Success × concussion/subluxation	7.05	0.0079*
Success × lateral luxation/intrusion	–	0.1836

$P < 0.05$.

Disintegration of pulpal tissue due to tissue necrosis, even under an aseptic form, causes the production of irritating substances which, associated with the physical trauma of the structures, will allow inflammatory reactions to install. By means of chemical mediators in the inflammatory process, there will occur resorption of osseous tissue and root (internal and external inflammatory root resorption and fistula) as a way to eliminate the causal agent. Left untreated, the root of the traumatized deciduous tooth will be absorbed at a speed directly proportional to the seriousness of trauma and the already installed inflammation.

Among pathologic root resorptions, replacement was the most frequent, corresponding to 22% of diagnosed sequelae, to be followed by external inflammatory root resorption (13.6%) and internal inflammatory root resorption (1.7%) (Table 5).

Table 4. Numerical and percentage distribution of traumatized deciduous teeth in relation to sequelae and the time elapsed until the first professional help

	Time elapsed between occurrence of injury and first visit						
Sequelae	Until 15 days	Between 16 and 45 days	Between 46 days and 4 months	Between 5 and 8 months	Between 9 and 12 months	More than de 12 months	Total (%)
MO	10 (58.8)	2 (11.8)	2 (11.8)	2 (11.8)		1 (5.8)	17 (100)
CD	4 (30.8)	1 (7.7)	1 (7.7)	2 (15.3)	1 (7.7)	4 (30.8)	13 (100)
PS	1 (50)			1 (50)			2 (100)
GI		1 (100)					1 (100)
GR		1 (100)					1 (100)
FI						1 (100)	1 (100)
PBR	1 (100)		1 (100)				2 (100)
IR						1 (100)	1 (100)
IRR	4 (50)	1 (12.5)		1 (12.5)		2 (25)	8 (100)
SRR	4 (30.8)		2 (15.3)	3 (23.1)	1 (7.7)	3 (23.1)	13 (100)
Total	24 (40.7)	6 (10.2)	6 (10.2)	9 (15.2)	2 (3.4)	12 (20.3)	59 (100)

Values are represented as *n* (%). CD, crown discoloration; FI, fistula; GI, gingival inflammation; GR, gingival recession; IR, internal root resorption; IRR, inflammatory root resorption; MO, mobility; PBR, periapical bone rarefaction; PS, percussion sensitivity; RRR, replacement root resorption.

Table 5. Numerical and percentage distribution of traumatized deciduous teeth in relation to sequelae and kind of trauma as diagnosed in the first visit

	Type of trauma								
Sequelae	CF	CFEx	FR	C	S	LL	I	A	Total (%)
MO		2	3		7	4	–	1	17 (27.1)
CD		2	1	1	4	3	2	–	13 (23.7)
PS		1						1	2 (3.4)
GI			1						1 (1.7)
GR			1						1 (1.7)
FI	1								1 (1.7)
PBR			1		1				2 (3.4)
IR						1			1 (1.7)
IRR		2			3	2	1		8 (13.6)
RRR			1	5	4	2	1		13 (22)
Total (%)	1 (1.7)	7 (11.8)	8 (13.6)	6 (10.2)	19 (32.2)	12 (20.3)	4 (6.8)	2 (3.4)	59 (100)

A, avulsion; C, concussion; CD, crown discoloration; CF, crown fracture without pulp exposure; CFEx, crown fracture with pulp exposure; FI, fistula; GI, gingival inflammation; GR, gingival recession; I, intrusion; IR, internal root resorption; IRR, inflammatory root resorption; LL, lateral luxation; MO, mobility; PBR, periapical bone rarefaction; PS, percussion sensitivity; RF, root fracture; RRR replacement root resorption; S, subluxation.

Differently from inflammatory resorption, which can be associated with the appearance of a fistula, the replacement resorption occurs in a 'silent' way, that is, no alteration is observed clinically. Alteration happens through necrosis of the periodontal ligament, when contact occurs between cementum and bone (ankylosis), the root being then absorbed on account of osseous turnover (20).

When the pedodontist is consulted because of an increase in tooth mobility, signs of root resorption will already be present. Replacement root resorption presents radiographically as a bevel, with a sharp apical and/or middle third of the root. Upon intervention with periodical changes of calcium hydroxide in that (or those) third(s) where replacement root resorption has already commenced, no paralyzation of the resorption will occur. Usually, paralyzation will happen at the root height where the periodontal ligament is still preserved (Table 1).

This research has somehow made evident how careful we must be regarding the diagnosis of pulp conditions. As vitality tests are not too reliable when conducted on children, we wait for clinical and radiographic indications of a compromised pulp, and this does not always guarantee we will find necrotic pulp tissue (Table 6). The kind of pathologic root resorption and the presence of periapical lesion are not the determinants of tooth vitality, with emphasis on replacement root resorption, which presented 33.3% of vital cases at the moment of opening. These results are in agreement with a case presented by Herd (21) who, in reporting the resorption process, showed that indifferent of the material deposited on the root during the process, apical resorption is likely to start before pulp necrosis, since the mediators of pulp inflammation act as a whole upon the vascular nervous bundle.

The UFSC program to treat traumatized deciduous teeth preconizes also a differentiated protocol for

Table 6. Numerical and percentage distribution of traumatized deciduous teeth in relation to radiographically detected serious sequelae and to the pulpal condition at the moment of endodontic opening

	Pulp Conditions		
Sequelae	Not-vital	Vital	Total (%)
PBR	1 (50)	1 (50)	2 (100)
IR	– (0)	1 (100)	1 (100)
IRR	6 (75)	2 (25)	8 (100)
RRR	5 (38.5)	8 (61.5)	13 (100)
Total	12 (50)	12 (50)	24 (100)

Values are represented as *n* (%). IR, internal root resorption; IRR, inflammatory root resorption; PBR, periapical bone rarefaction; RRR, replacement root resorption.

Table 7. Associations to which the chi-square and Fisher's tests were applied, together with significance (*P*)

Association	Chi-square and Fisher's test	Significance level
Success × time elapsed until RWL	0.05	0.8199
Success × age	–	1.0000
Success × pulp condition	0.08	0.7776
Age × time elapsed until RWL	–	0.0028*

$P < 0.05$.

Fig. 1. Patient DSB (2 years old) traumatized the left central incisor (crown fracture with pulp exposition). Observe the inflammatory root resorption after 3 months of the trauma when the parents came to the Federal University of Santa Catarina.

Fig. 2. Endodontic treatment with zinc oxide and eugenol cement.

Fig. 3. Three month after the end of the endodontic treatment.

the endodontic treatment of vital and non-vital teeth. At the first pulpectomy session for necrotic teeth, we employed a 1:5 dilution of formocresol as a temporary dressing. This procedure seeks to fix and neutralize toxic products of tissue breakdown, of bacterial metabolism, and to reduce existing infection.

To perform the emptying, instrumentation, placement of inter-session dressing and final obturation of the canals, we must have the length of the field of action, that is, the length of the tooth to be endodontically treated. To that end, we measure the RWL similarly to what is made on permanent teeth, in accordance with the RWL measuring technique created by the UFSC. The adaptation of this technique (Ingle's) for deciduous teeth (UFSC technique) takes into consideration the apical reference points in accordance with the related radiographic anatomy, i.e.: (a) the radicular apex when no interference exists of the germ of the permanent tooth, mainly with very young patients; (b) the line that coincides with the radiopaque massive of pathologic radicular resorption, or (c) cases where

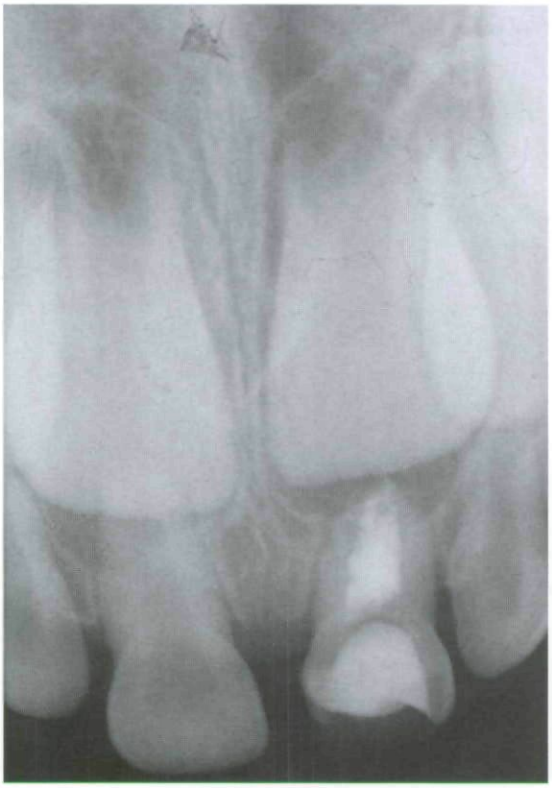

Fig. 4. Twelve months after the endodontic treatment.

Fig. 6. Eighteen months after the endodontic treatment.

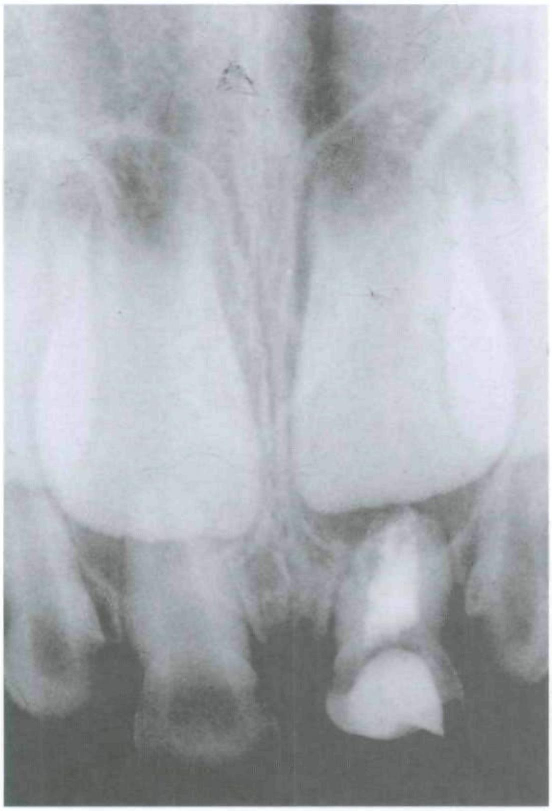

Fig. 5. Fifteen months after the endodontic treatment.

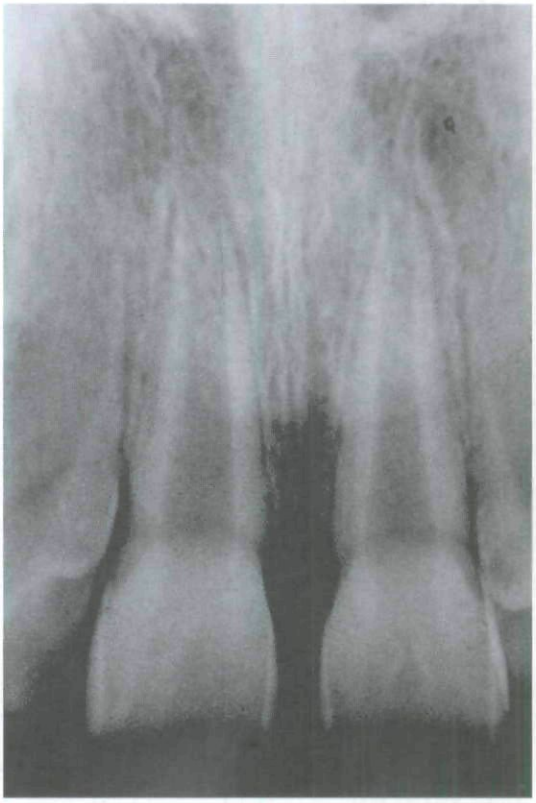

Fig. 7. Permanent teeth radiograph.

Fig. 8. Front view of permanent teeth.

Fig. 9. Patient TDV (3 years old) traumatized the left central incisor (lateral luxation). Observe the inflammatory root resorption after 6 months of the trauma when the parents came to the Federal University of Santa Catarina.

there is superposition of the permanent tooth, as beyond this line there will be physiologic resorption, either perforating or not. In spite of that, research has demonstrated the inexistence of a statistically significant relation between treatment success, the

Fig. 10. Inflammatory root resorption on left central incisor.

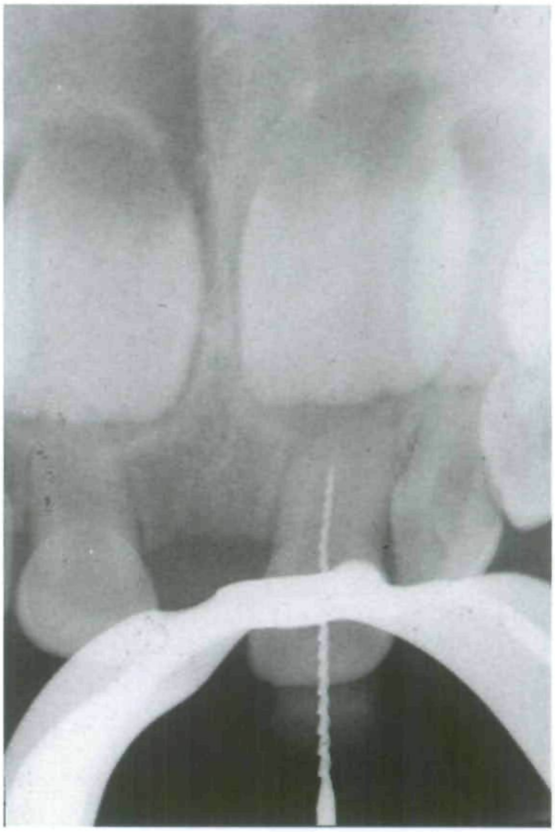

Fig. 11. Verify the work length.

Fig. 12. Calcium hydroxide dressing on left central incisor.

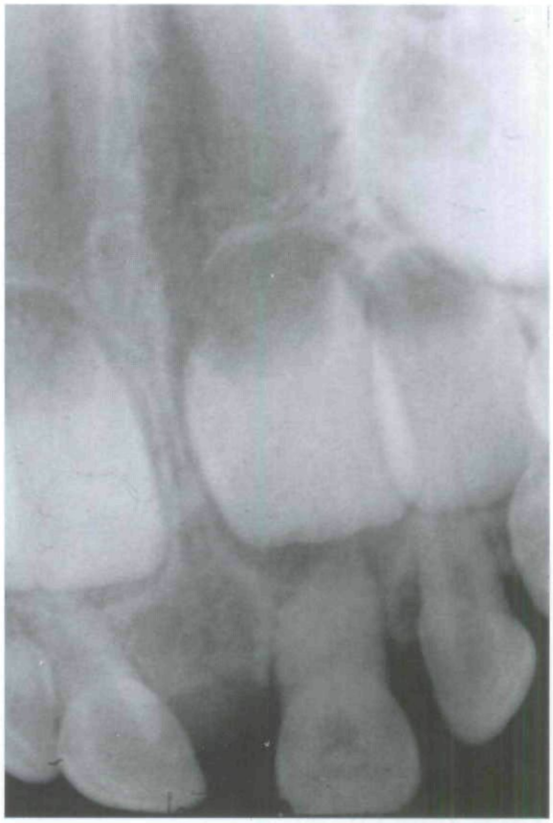

Fig. 13. Calcium hydroxide dressing on left central incisor (5 months after the beginning of the endodontic treatment).

time to assess the RWL (up to 1 month following the beginning of treatment), the patient's age (younger or older than 3 years of age), and the pulp condition (vital or non-vital) (Table 7). When pulp necrosis exists on account of trauma (Table 7), this necrosis is considered to be aseptic, since there is no infection of the outer medium, only the spots generated from pulp necrosis existing. It is possible, on account of this particular that the vital or non-vital condition of the pulp tissue at the time of opening has not interfered with the success of treatment. Even so, there are authors who, in spite of indicating the endodontic treatment of traumatized deciduous teeth, suggest exodontia be performed in cases where pulp necrosis is evident (4, 18).

It is important to observe none of the canals kept its full pulp content, having been emptied and instrumented along its working length for exploration, until the RWL is determined using the technique preconized by the UFSC. It is important to observe the age of the child and the time elapsed until the RWL is determined are statistically significant, suggesting the younger the child (below the age of 3) the greater the time to manage the child's behavior to perform the UFSC RWL technique, as the child cooperation and pleasant behavior become necessary, so as not to contaminate the root canal (Table 7).

For biomechanical preparation, the main canal was instrumented with circumferential filing of the walls using the first FF series to obtain clean and regular walls. This will enhance the tooth/obturation integration, reducing the interface of these structures, as pedodontics does not imply a compressive obturation technique.

The use of sodium hypochlorite, associated with instrumentation guided by the UFSC Protocol, has its efficiency attested to by the study of Baumgartner and Cuenin (22) where exposure of dentinal tubules was possible on all the instrumented faces, indifferent of the sodium hypochlorite solution concentration, making easier the diffusion of the temporary dressing to sites not reached by endodontic tools.

After being cleaned and instrumented, the root canal was filled with calcium hydroxide by means of a spiral lentulo (23). Calcium hydroxide dressings help to reduce or eliminate bacteria, as instrumentation and sodium hypochlorite are able to act upon the whole root canal system. When

Fig. 14. Calcium hydroxide dressing (12 months after the beginning of the endodontic treatment).

Fig. 15. Obturation with zinc oxide and eugenol cement (19 months follow-up).

overflowing, calcium hydroxide will harm the periapical tissues; on external root resorptions in the apical region where chronic pulp infection is present, calcium hydroxide shows success in detaining resorption and in forming a barrier between the canal and the periodontium (24).

The importance of using calcium hydroxide was also observed by Croll et al. (25) in their studies, where the canals of deciduous teeth with a necrotic pulp were included (19). The bactericide property is due to the high pH of calcium hydroxide; its effect on osteoblasts and odontoblasts is not yet clear (24). It has been demonstrated *in vitro* that the action of calcium hydroxide on pathologic root resorptions occurs through the inhibition of the macrophage's adherence capacity, which is the first stage of a phagocytosis process. Thus, calcium hydroxide applied intracanal or directly on pulpal tissue reduces the inflammatory reaction of periapical and pulpal tissues (26).

In addition, calcium hydroxide in association with hydrosoluble vehicles such as propyleneglycol, presents better biocompatibility, that is, antimicrobial qualities and tissue repair induction (27).

The objective in using a dense calcium hydroxide paste (a large amount of powder incorporated to propyleneglycol) is a longer time in the canal and the resulting reduction in the number of changes and interventions along the treatment.

Endodontic intervention such as proposed by the UFSC Protocol recommends monthly changes of calcium hydroxide dressings for 12 months. On radiographs taken every month before changing the dressing, it was often possible to observe the presence of calcium hydroxide paste in the canal, obviating thus the need for change. Such fact is to be attributed to the dense consistence of the calcium hydroxide paste. On Routine 1 we have arbitrated the placement of calcium hydroxide for 12 months for all kinds of trauma; in spite of the inexistence of scientific parameters to support shorter periods of time, we observed success to be attained in cases where calcium hydroxide was employed for less than 6 months. For Routine 2 of the Protocol, each case shall be individually treated as per kind of trauma, (fracture or luxation), and the definitive obturation will be made after repair of the sequelae which originated endodontic intervention.

The teeth were mostly obturated with straight ZOE, of lesser consistence to make its later

Fig. 16. Thirty-three months follow-up after the endodontic treatment.

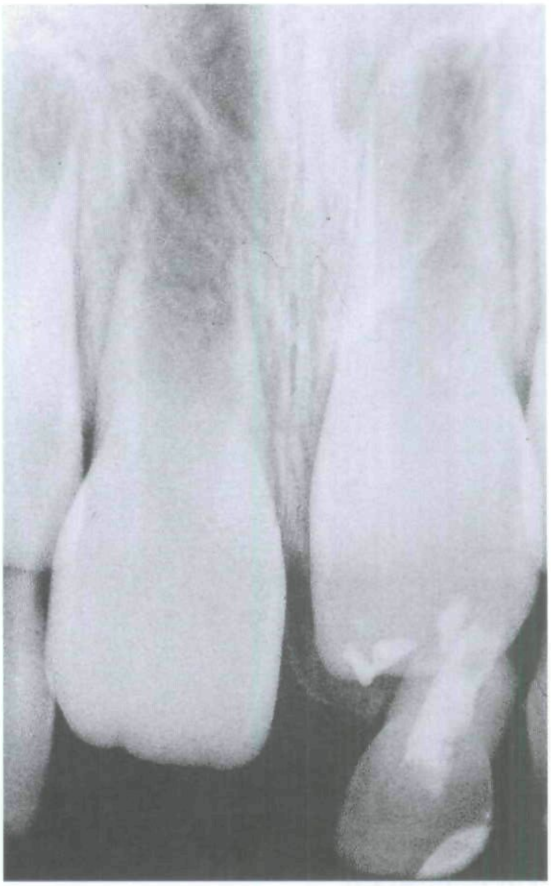

Fig. 17. Thirty-seven months follow-up after the endodontic treatment.

resorption easier. For those cases where resorption (pathologic or physiologic) existed in half or more than half the root of the deciduous tooth, obturation was made with a thick paste of zinc oxide/calcium hydroxide/olive oil, so as not to introduce obstacles in the path of the permanent successor. To prevent overflow of the cement or obturation paste, extra care was taken in calibrating the lentulo instrument (1 mm shorter of the MWL).

Among failures, we had cases where the time between trauma and beginning of endodontic treatment at the UFSC was quite long. The first care was often given on places close to the children's home, without a follow-up protocol. Treatment at the UFSC, in most cases, was sought when clinical signs of alteration (marked mobility, fistula, etc.) became visible. Following radiographic examinations at the university, some of the cases showed to have reached advanced stages, making treatment progress doubtful.

Considering the inexistence in the literature of protocols for the treatment of traumatized deciduous teeth, and the need for scientific studies that establish a conduct, the UFSC Protocol for a traumatized deciduous tooth, through Routine 1 (followed up to now), and Routine 2 (to be established from present study on), offers guidelines to those professionals who are interested in ministering adequate treatment to trauma-afflicted children.

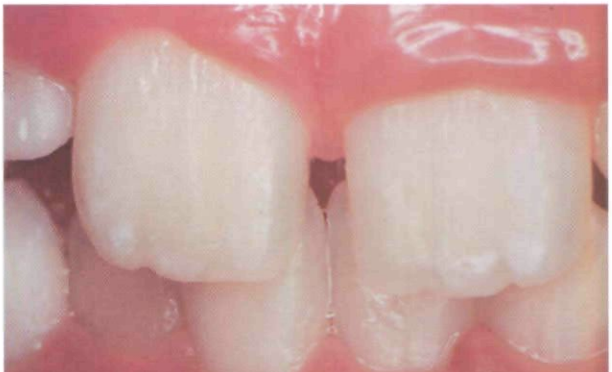

Fig. 18. Front view of permanent teeth.

There are strong indications that this is the adequate course for the treatment of traumatized deciduous teeth, in a scientific and biologic way, where the particularities of the deciduous tooth, properly considered, are not an obstacle for correct treatment.

It is possible the UFSC Protocol is too daring for some professionals, and too complex to be applied to small children. We can say, based on our experience, that this is what sets apart the pedodontist from the other clinicians. If a child could sit on the dentist's chair and permit to be treated without offering any opposition, there would be no need for pedodontics. What establishes the difference between this and the other specialists is the capacity to perform biologically correct procedures on patients who, very often, do not offer cooperation. Even so, we have had excellent surprises along the application of the Protocol, when very small children exhibited extraordinary behavior, and all those who initially showed a difficult behavior had an improved attitude, without exceptions, as consultation advanced.

We can no longer accept that palliative treatments, destined to failure, keep on being performed under the excuse of ignoring histopathologic aspects and the behavior of the child. The younger a child is, the more difficult his/her behavior will be, but maintaining the traumatized tooth in the buccal cavity is of the utmost importance.

Parents, with very few exceptions, are all in favor of maintaining the treated deciduous tooth in the buccal cavity. They often request the tooth be not extracted but rather treated, even under extremely unfavorable conditions.

Another important factor is that no Protocol for a traumatized deciduous tooth shall be performed unless endodontic treatment aspects have been previously established.

In establishing its Protocol, the UFSC certainly took the first step to create not just a treatment protocol but also a consciousness to maintain and treat the healthy traumatized deciduous tooth in the buccal cavity for children of all ages.

References

1. Bijella MFT, Yared FN, Bijella VT, Lopes ES. Occurrence of primary incisor traumatism in Brazilian children: a house-by-house survey. ASDC J Dent Child 1990;21:424–7.
2. Montalvo-Polk A, Kittle PE. Impaction and malformation of a maxillary central incisor: sequelae of trauma. ASDC J Dent Child 1991;60:29–32.
3. Soporowski NJ, Allred EN, Needleman HL. Luxation injuries of primary anterior teeth – prognosis and related correlates. Pediatr Dent 1994;16:96–101.
4. Fried I, Erickson P. Anterior tooth trauma in the primary dentition: incidence, classification, treatment methods, and sequelae: a review of the literature. J Dent Child 1995;62:256–61.
5. Wilson CFG. Management of trauma to primary and developing teeth. Dent Clin North Am 1995;39:133–67.
6. Antenucci F, Giannoni M, Baldi M. Lussazioni dei denti anteriori decidui. Dent Cadmos 1992;58:50–58.
7. Walter LRF, Ferelle A, Issao M. Odontologia para o bebê: odontopediatria do nascimento aos 3 anos, 1st edn. São Paulo: Artes Médicas; 1997, pp. 153–82.
8. Borum MK, Andreasen JO. Sequelae of trauma to primary maxillary incisors. I. Complications in the primary dentition. Endod Dent Traumatol 1998;14:31–44.
9. Roberts G, Longhurst P. Oral and Dental Trauma in Children and Adolescents. Oxford: Oxford University Press; 1996, pp. 25–36.
10. Weiger R, Heuchert T. Management of an avulsed primary incisor. Endod Dent Traumatol 1999;15:138–43.
11. Mathewson RJ, Primosch RE. Fundamentals of Pediatric Dentistry, 3rd edn. Chicago, IL: Quintessence; 1995, p. 400.
12. Andreasen JO. Lesiones traumáticas de los dientes, 3rd edn. Barcelona: Labor; 1984, p. 478.
13. Garcia-Godoy F. A Classification for traumatic injuries to primary and permanent teeth. J Pedod 1981;5:295–7.
14. Duarte DA, Bünecker MS, Sant'Anna GR, Suga SS. Caderno odontopediatria de – Lesões traumáticas em dentes decíduos: tratamento e controle, 1st edn; 2001, São Paulo:Santos, p. 45.
15. Joho JP, Marechaux SC. Trauma in the primary dentition: a clinical presentation. ASDC J Dent Child 1980;47:167–74.
16. Coll JA, Josell S, Nassof S, Shelton P, Richards MA. An evaluation of pulpal therapy in primary incisors. Pediatr Dent 1988;10:178–84.
17. Harding AM, Camp JH. Traumatic injuries in the preschool child. Dent Clin North Am 1995;39:817–35.
18. McTigue DJ. Introdução ao trauma dentário:tratamento de lesões traumáticas na dente decíduo. In: Pinkham JR, Casamassimo PS, Fields HW, McTigue DJ, Nowak A, eds. Odontopediatria da infância à adolescência, 2nd edn. São Paulo: Artes Médicas; 1996, pp. 232–45.
19. O'Riordan M. Apexification of deciduous incisor. J Endod 1980;6:607–9.
20. Andreasen JO, Andreasen FM. Texto e atlas colorido de traumatismo dental. Porto Alegre: Artmed Editora, 2001.
21. Herd JR. Apical tooth root resorption. Aust Dent J 1971;16:269–74.
22. Baumgartner JC, Cuenin PR. Efficacy of several concentrations of sodium hypochlorite for root canal irrigation. J Endod 1992;18:605–12.
23. Aylard SR, Johnson R. Assessment of filling techniques for primary teeth. Pediatr Dent 1987;9:195–8.
24. Marais JT. The use of calcium hydroxide as a dressing in root canal treatment. J Dent Assoc S Afr 1996;51:593–9.
25. Croll TP, Pascon EA, Langeland K. Traumatically injured primary incisors: a clinical and histological study. ASDC J Dent Child 1987;54:401–21.
26. Segura JJ, Llamas R, Rubio-Manzanares AJ, Jimenez-Planas A, Guerrero JM, Calvo JR. Calcium hydroxide inhibits substrate adherence capacity of macrophages. J Endod 1997;23:444–6.
27. Estrela C, Pecora JD, Souza-Neto MD, Estrela CR, Bammann LL. Effect of vehicle on antimicrobial properties of calcium hydroxide pastes. Braz Dent J 1999;10:63–72.