Survival analysis of endodontically treated traumatized primary teeth

Rocha MJC, Cardoso M. Survival analysis of endodontically treated traumatized primary teeth.

Abstract – The present study aimed to verify the factors that interfere with the success of endodontic treatment of traumatized primary teeth as well as to determine the success level of the proposed treatment, through survival analysis. The research was conducted through the analysis of dental traumatism records and attached radiological exams of patients assisted by the Assistance Program for the Traumatized Patient at UFSC (Universidade Federal de Santa Catarina). Fifty-one dental records of patients aged between 10 and 60 months were analyzed. These patients had their traumatized teeth endodontically treated ($n = 51$), according to the indications of the UFSC protocol. In order to evaluate possible interference factors affecting the success of the endodontic treatment, the following items were analyzed: age of the child at the beginning of the endodontic treatment (over or below 36 months), trauma type (mild or severe) pathological root resorption type (replacement or inflammatory), localization of the pathological root resorption (in the apical third or in the middle third), bone resorption (absent or present), alteration of the soft tissue (absent or present), condition of the pulp tissue (vitality or necrosis) and trauma recurrence (absent or present). Through the chi-squared test ($\chi^2 = 9.594$, $P < 0.05$) and survival analysis, it was verified that trauma recurrence in the same tooth is a factor that interferes in the success of endodontic treatment. It was also observed, through survival analysis, that levels of success of endodontic treatments are stabilized in the 19th month. A period of 48 months of follow up was observed. It was also verified that most failures occurred between the 7th and 12th months counting from the beginning of the endodontic treatment. It was concluded that endodontic treatment of traumatized primary teeth, performed according to the UFSC protocol, enables the maintenance of the traumatized tooth in acceptable conditions in the buccal cavity up to its physiological resorption, and that trauma recurrence is a factor that leads to treatment failure.

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Key words: trauma; primary teeth; endodontic treatment

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Accepted 25 October, 2005

The attention directed to patients affected by dental traumatism may be divided into two different stages. The first one consists of the immediate treatment that occurs moments after the trauma, by means of clinical-radiological exams, dental replacement (including reimplant) and splint, when necessary. The second one, called mediate treatment, occurs along with the follow-up period of traumatized teeth, which may develop some kind of pathological alteration such as pulp necrosis, abscess, fistula, mobility increase, periapical lesion and pathological root resorptions (1, 2).

The proposed treatment for traumatized permanent teeth that present such alterations is endodontic

treatment. For primary teeth, the literature recommends either endodontic treatment or extraction of the affected tooth. Authors that choose extraction as the appropriate treatment argue that maintaining the tooth affected by necrosis in the buccal cavity will bring problems to the succeeding permanent tooth (3–11). Those that choose endodontic treatment base their actions on the elimination, through the biomechanical preparation of the root canal, of either the infection or the necrotic pulp tissue, providing the necessary conditions to keep the tooth in the buccal cavity, without any kind of damage to the succeeding tooth (12–24).

Although opinions diverge, there are no longitudinal follow-up studies on endodontically treated traumatized primary teeth to determine whether or not there are benefits to treating them. The success rate of treating teeth affected by sequelae deriving from traumas, such as periapical lesions and pathological resorptions, has been little researched (23).

In teeth indicated for endodontic therapy, the presence of pulp necrosis, infection, periapical lesions or pathological root resorptions may interfere directly or indirectly with the repair process after the treatment. Similar to what occurs to the prognostic for teeth with endodontic indication caused by infection level deriving from caries lesion (25–27), the prognostic for endodontic treatments performed in traumatized teeth may also be doubtful. This may occur because of the damage that trauma impact causes in the tissues, leading to inflammatory reactions, or even because of the presence of an infection that occurred after the trauma.

The objective of this study was to determine if endodontic treatment performed according to the UFSC (Universidade Federal de Santa Catarina) Protocol for the Treatment of Patients with Traumatized Primary Teeth allowed the maintenance of the traumatized tooth in the buccal cavity without radiological or clinical sequelae, as well as to identify, among the failure cases, which factors interfered with the endodontic treatment.

Methodology

The investigation was carried out through the analysis of 371 dental reports of children assisted by the Assistance Program for the Traumatized Patient between August 1998 and March 2004. This Program is part of the Pediatric Dentistry Department of UFSC and was created in August 1998. All the patients with traumatized teeth that seek dental treatment at the University are referred to the Program, which has an established assistance protocol for both permanent and primary teeth.

Patients with traumatized primary teeth indicated for endodontic treatment are those who present coronal fracture and pulp exposition, periapical bone rarefaction, submucosal abscess presence (associated or not with the presence of fistula), replacement root resorption or inflammatory pathological root resorption (external or internal). All the teeth that present one or more of these clinical and/or radiological symptoms are treated according to the UFSC protocol (2). Extraction is the treatment of choice in cases in which the root resorption is greater than 2/3, there is a coronal/root fracture, or the tooth presents excessive mobility. Endodontic treatment is contraindicated in such cases.

This study included only patients under treatment in the Assistance Program for the Traumatized Patient up to March 2004 and only patients under endodontic treatment according to the UFSC protocol. The exclusion criteria were: incomplete data in the Dental Traumatism Report; patients who left the Program; patients who were submitted to endodontic treatment according to other protocols; those whose traumatized teeth presented old restorations; and patients with root fracture.

The Dental Traumatism Reports of the patients assisted by the Program and the patients' radiological exams were used to collect the data. Primary teeth that were under treatment at the time of analysis had X-ray exams performed immediately before the beginning of the endodontic treatment. The most recent X-ray exam of the calcium hydroxide dressing was also used in the evaluation. In cases in which the tooth had been endodontically treated and restored, the evaluation was based on the analysis of two radiographic exams. The evaluation performed immediately before the beginning of the endodontic treatment was the first to be analyzed. The second analysis was performed on the radiographic exam performed before extraction or exfoliation. In cases in which the restored tooth was present in the buccal cavity, the last radiological follow-up exam was evaluated. An X-ray viewing box and magnifying lens were used in all analyses and all collected data was recorded in a preformatted table.

Forty-one children assisted by the Program aged between 10 and 60 months constituted the study population, totaling 51 traumatized primary teeth.

The following clinical-radiological factors were considered as possible interference factors with regard to the endodontic treatment: the age of the child at the time of endodontic intervention (over or under 36 months); trauma type (mild or severe); pathological root resorption type (replacement or inflammatory); localization of the pathological root resorption (apical third or middle third); bone resorption associated to root resorption (present or

absent); submucosal abscess and/or fistula (present or absent); pulp condition (vitality and necrosis); and trauma recurrence (present or absent). When the collected data did not fit these classifications, they were listed under the title of 'others' (Figs 2–6).

Trauma types were classified as mild (coronal fractures without pulp exposition, concussion and subluxations) and severe (coronal fracture with pulp exposition, intrusion, extrusion and avulsion). The loss of root structure and its substitution for bone tissue (radiopaque apical zone without relation to the permanent tooth germ) characterized replacement resorption. This evidence was detected through the analysis of radiographic exams. Inflammatory resorption was characterized by the loss of root tissue associated with the loss of bone tissue (periapical radiolucency zone without relation to the permanent tooth germ).

During the endodontic opening, pulpal tissue was considered alive if it presented evidence of bleeding. Blood quantity and color (cyanotic red, yellowish or light red) were not considered relevant. Pulpal tissue was classified as affected by necrosis in the cases in which pulpal tissue 'body' presented a total white aspect, because of the rupture of the nervous-vascular bundle (generally characterizing aseptic necrosis), and in those in which pulpal tissue was disorganized, having a liquefied aspect (generally septic necrosis). Data was also collected on the recurrence of dental traumatism before, during and after the endodontic treatment.

Endodontic treatment was considered satisfactory if patients presented: (i) an endodontically treated tooth that remained in the buccal cavity until the succeeding permanent tooth reached Nolla stages 6 or 7; (ii) a tooth whose endodontic treatment was completed, which remained in the buccal cavity without any signs of pathological alteration and whose succeeding permanent tooth was below Nolla stage 7; and (iii) a primary tooth still under endodontic treatment (calcium hydroxide dressing) that did not present any pathological alteration aspect, such as the absence of periapical bone rarefaction because of the treatment of the pre-existing lesion, no lesion manifestation after the intervention, or even the deceleration of pathological root resorption.

The chi-squared test was used to evaluate the possible interference factors regarding the endodontic treatment. Survival analysis was also used to investigate the amount of time that teeth submitted to endodontic treatments remained in the buccal cavity. First, the actuarial method was used to determine the probability estimate for general tooth permanence and for each of the possible interference factors. Then, the Mantel–Haenszel test was used to compare both distributions (cohort point) of the survival analysis of each of the possible factors that could interfere with the endodontic treatment.

According to the resolution of the Conselho Nacional de Saúde (CNS), (Brazilian Council of Health), dated October 10, 1996, the research project was submitted for the appraisal of the Comitê de Ética em Pesquisa com Seres Humanos da Universidade Federal de Santa Catarina (UFSC's Human Research Ethics Committee), and was granted approval number 174/2003.

Results

Forty-one children formed the study group: 51.2% were male and 48.8% were female. Among them, 10 presented two traumatized teeth; totaling 51 traumatized primary teeth. Among the 51 analyzed teeth, the ones with the highest index of traumas were the right maxillary central incisors and the left maxillary central incisors, in 49% and 47.1% of the cases, respectively. With regard to the age of the children at the beginning of endodontic treatment, 18% were under 36 months of age, while 82% were older.

Concerning trauma type, 56.9% were affected by mild traumas while 43.1% presented severe traumas. For the type of identified root resorption, 27.5% were replacement resorptions and 66.7% were inflammatory external resorptions, among which 47.1% were located in the apical third and 39.2% in the middle third. In 45.1% of the cases, it was verified that bone resorption associated to root resorption occurred.

In 80.4% of the cases, the presence of submucosal abscess and/or fistula was not identified. After accessing the pulpal chamber, it was observed that the pulpal tissue was alive in 33.3% of the cases and necrotic in the remaining 66.7%.

Among the 51 teeth analyzed, 43.1% presented trauma recurrence affecting the same tooth before or after the beginning of the endodontic treatment. In nine of these cases, the second trauma led to the immediate extraction of the dental element (during or after the endodontic treatment) because of the severe damage in the support tissues.

In 64.7% of the cases, the endodontic treatment was considered successful, whereas it failed in 35.3% of them. Table 1 describes the percentage of success and failure for each of the factors that could interfere with the endodontic treatment.

Using the chi-squared test, it was possible to associate the treatment's success or failure to each possible interference factor. Only trauma recurrence revealed a statistically significant value ($\chi^2 = 9.594$, $P < 0.05$). Among the other factors, such as trauma type, periapical lesion presence,

Table 1. Description of the factors that may interfere in the success of the endodontic treatment of traumatized primary teeth according to the Universidade Federal de Santa Catarina protocol ($n = 51$)

Factors	Success (%)	Failure (%)
Age at the moment of the endodontic intervention		
≤36 months	05 (55.5)	04 (44.5)
>36 months	28 (68.3)	13 (31.7)
Others	01 (100)	00
Trauma type		
Uncomplicated	18 (62.1)	11 (37.9)
Complicated	15 (68.2)	07 (31.8)
Pathologic root resorption type		
Replacement	09 (64.3)	05 (35.7)
Inflammatory	21 (61.8)	13 (38.2)
Others	03 (100)	00
Localization of the pathologic root resorption		
Apical third	15 (62.5)	09 (37.5)
Middle third	13 (65)	07 (35)
Others	05 (71.4)	02 (28.6)
Bone resorption		
Absent	21 (75)	7 (25)
Present	12 (52.2)	11 (47.8)
Submucosal abscess and/or fistula		
Absent	26 (63.4)	15 (36.6)
Present	07 (70)	03 (30)
Pulp condition		
Vital	11 (64.7)	06 (35.3)
Necrotic	22 (64.7)	12 (35.3)
Trauma recurrence		
Absent	24 (82.8)	05 (17.2)
Present	09 (40.9)	13 (59.1)

submucosal abscess and/or fistula presence and pulpal tissue condition, no statistical associations were found.

Teeth submitted to endodontic treatment were analyzed through the survival analysis (actuarial method). It may be seen in Table 2 that most of the treatment failures occurred in the first year, and that after 18 months, the number of successful cases was established. Thus, it was verified that, from the 19th month on, no failure cases were registered and treatment success was maintained in 65% of the cases until 48 months.

Survival analysis was also performed for each of the possible factors that could affect the endodontic treatment. Table 3 presents the cumulative percentages of endodontic treatment success in each of the periods for each of the possible factors. As shown in Table 2, it may be observed that the percentage of success became stable in the 19 month for all possible associated factors. For some of the factors, although, the success stabilization was observed from the 13 month after the beginning of the endodontic treatment (Table 3).

Table 2. Survival analysis for the teeth that were submitted to endodontic treatment ($n = 51$)

Months	Teeth (n)	Failure (n)	Lost	Failure (%)	Success (%)	Cumulative %
0–6	51	3	0	06	94	94
7–12	48	9	0	19	81	76
13–18	39	4	0	10	90	69
19–24	35	2	0	06	94	65
25–30	33	0	0	00	100	65
31–36	33	0	0	00	100	65
37–42	33	0	0	00	100	65
43–48	33	0	0	00	100	65

The Mantel–Haenszel test was used to verify the statistical difference between the life tables of each of the factors (Table 3). A statistically significant difference was noticed only for trauma recurrence, as can be seen in Fig. 1. When teeth with only one episode of trauma were compared with those with trauma recurrence, it was possible to observe a statistically greater success rate in the endodontic treatment in teeth which were affected by trauma just once.

Discussion

Children's behavior during dental assistance and the temporality of the primary tooth in the buccal cavity have been considered reasons to explain dental professionals' resistance to using attention protocols for traumatized teeth, especially when there is evidence of damage to the pulpal tissue and endodontic intervention is considered necessary.

Pulpal therapy in primary teeth aims to prevent an early loss of the dental element, thereby preserving dental function and aesthetics without risking the succeeding tooth germ health (Figs 1–6) (12, 14, 15, 17, 22, 23, 28–30).

In pediatric dentistry, children are considered 'babies' until they reach 36 months. This age is chosen as the cohort point. Because of the difficulty of treating children at such young ages (31, 32), the use of special strategies such as conscious sedation with nitrous oxide may be necessary (29). In most cases, after 36 months the dentist may count on the participation and co-operation of the patient. Young patients' acceptance of treatment can also be improved through the use of conditioning techniques (6, 7, 11, 23). Nevertheless, parents' involvement remains essential in any stage of dental treatment, no matter how old the child is. Yet, in the present study, the age at the beginning of the endodontic intervention was not a significant factor in the success of the treatment of traumatized primary teeth.

The type of trauma was also chosen as a possible interference factor. Previous studies on permanent teeth indicate that traumas with dental displacement present a greater impairment of the root surface and the periodontal ligament, leading to pathological resorptions that in many cases interfere with the prognosis (16, 30, 33, 34). In the present study, there was no significant difference between

Table 3. Cumulative survival analysis percentage of possible interfering factors in endodontic treatment ($n = 51$)

	Cumulative %								
Possible factors	0–6 (%)	7–12 (%)	13–18 (%)	19–24 (%)	25–30 (%)	31–36 (%)	37–42 (%)	43–48 months (%)	*P*
Age ($n = 50$)									NS
<36 months	100	89	78	56	56	56	56	56	
>36 months	93	76	68	68	68	68	68	68	
Trauma type ($n = 51$)									NS
Uncomplicated	97	83	69	62	62	62	62	62	
Complicated	91	77	68	68	68	68	68	68	
Root resorption ($n = 48$)									NS
Replacement	100	79	64	64	64	64	64	64	
Inflammatory	91	74	68	62	62	62	62	62	
Localization resorption ($n = 44$)									NS
Apical third	92	67	67	63	63	63	63	63	
Middle third	100	90	70	65	65	65	65	65	
Bone resorption									NS
Absent	87	61	61	52	52	52	52	52	
Present	100	79	64	64	64	64	64	64	
Submucosal abscess/fistula									NS
Absent	93	76	66	63	63	63	63	63	
Present	100	80	80	70	70	70	70	70	
Pulp condition ($n = 51$)									NS
Vital	94	82	65	65	65	65	65	65	
Necrotic	94	74	71	65	65	65	65	65	
Trauma recurrence									0.01
Absent	93	90	86	86	86	86	86	86	
Present	95	59	50	41	41	41	41	41	

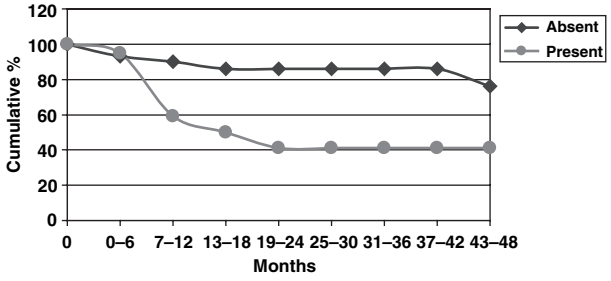

Fig. 1. Survival analysis for trauma recurrence ($P < 0.001$).

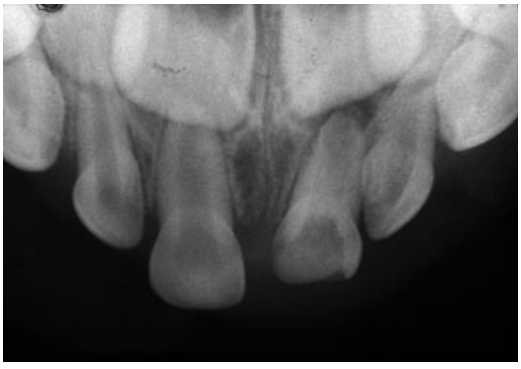

Fig. 2. Crown fracture with pulpal exposition of the maxillary left central incisor with periapical bone rarefaction after trauma. Age, 2 years and 8 months.

trauma types as to the success of the endodontic treatment when mild and severe traumas were compared.

Fig. 3. After endodontic treatment and obturation.

Concerning replacement and inflammatory root resorptions, there are different treatment proposals: follow up, endodontic treatment and extraction. When the presence of an inflammatory root resorption is detected, there is a consensus in the literature which indicates extraction or endodontic treatment (35, 36). For replacement root resorptions, however, some authors do not indicate endodontic treatment (37–41). This is because of the belief that inflammatory resorption is related to pulpal necrosis; in teeth affected by replacement root resorption the pulpal tissue may remain vital.

Fig. 4. Forty months of follow up. Physiological root resorption.

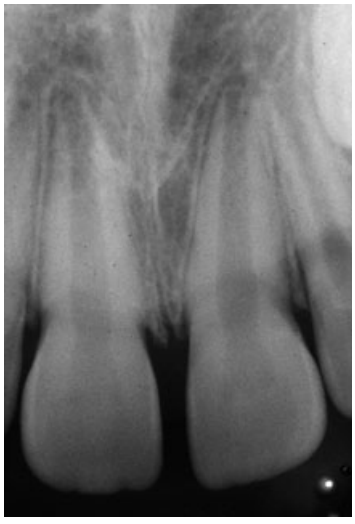

Fig. 5. Radiographic after eruption of the permanent successors after 48 months of follow up.

Fig. 6. Clinical view of the permanent successors without alterations.

In the UFSC protocol for the Treatment of Traumatized Patients, there are two distinct situations regarding replacement root resorption. First, there are cases in which the replacement resorption is diagnosed on the lateral surface of the root, but the integrity of the root canal is retained, as the pulp remains vital. When there is pulpal tissue vitality, there is a layer of odontoblasts that separate pulpal tissue from the pre-dentin. As the clastic cells have the capacity to reabsorb mineralized tissue only, the root canal is preserved (42, 43). The radiological observations suggest that when the endodontic treatment was performed in such cases, acceleration of the pathological resorption was observed, leading to early dental loss. This is because during the instrumentation of the root canal, along with the pulp removal, the odontoblast layer is also removed. Thus, the pathological root resorption increases, including the area of the root canal. This fact explains why endodontic treatments are not indicated in such cases (43).

There are also cases in which replacement resorptions are present in the apical region, incorporating the root canal in the resorption process, which suggests that pulpal tissue is affected by necrosis (43). In such situations, endodontic treatment is indicated.

In regard to the localization of the root resorption, some authors advocate that the presence of pathological resorption is one of the contraindications to endodontic treatment (6, 15, 18, 44). The present study verified the success of endodontic treatment for teeth in which the resorption was located in both the apical and medium thirds. This indicates that even in cases in which pathological resorption encompasses half of the root, endodontic treatment is still able to keep the tooth in healthy conditions in the buccal cavity. In cases in which the resorption is located in the cervical third, the UFSC protocol indicates extraction, as dental maintenance could allow access to microorganisms through the gingival sulcus.

Authors such as Joho and Marechaux (3), Sonis (5) and Wilson (45) contraindicate endodontic treatment in cases of pulpal necrosis evidenced by the presence of periapical lesion and submucosal abscess and/or fistula. The findings in the present study show that pulpal necrosis, associated or not with the presence of periapical lesion and submucosal abscess and/or fistula, are not factors that contraindicate endodontic treatment, as they presented no difference when compared with the group that presented vitality. This result agrees with the results found in other studies (21).

The worries of most professionals are related to possible sequelae of the succeeding permanent tooth germ (9, 11, 46). Yet, in more than 50% of the 51 cases submitted to endodontic treatment in the present study, the permanent tooth had already erupted. Furthermore, none of the cases presented

damage to the dental structure. It must be clear that the endodontic treatment is able to remove the cause that generated the periapical lesion. That is, it removes infected or non-infected pulpal tissue with necrosis. Once the cause is removed, the lesion can be repaired, thus preserving the permanent tooth germ. It is important to emphasize that the maintenance of a tooth affected by necrosis without endodontic treatment, or with inadequate treatment, may bring sequelae to the germ (17).

Trauma recurrence in the same tooth was not evaluated in permanent teeth. Clinical observations obtained through the UFSC protocol have shown that a great number of children sustain trauma recurrence and that most of the affected teeth are lost prematurely (47, 48). Thus, trauma recurrence was also considered a probable interfering factor in the endodontic treatment's success. This study has shown that teeth affected by more than one trauma presented a greater failure rate in the endodontic treatment, a fact unrelated to whether the trauma occurred before or after the beginning of the treatment. It was evident that teeth affected by trauma recurrence were kept in the buccal cavity for a shorter time (extraction was needed) when compared with teeth that suffered just one traumatism.

At the moment the pediatric dentist is required to treat a traumatized primary tooth, he/she may warn parents about the possibilities of trauma recurrence and the consequences it may bring for the child and for the prognostic of the endodontic treatment of the primary tooth. On the other hand, for cases of traumatized primary teeth with a trauma recurrence history, the professional must warn parents about the small chance of success endodontic treatments offer in such cases.

Through survival analysis it was observed that endodontic treatment success was stable from the 19th to 48th month after the beginning of the treatment. Such conclusions are possible only when treated patients are observed over a long follow-up period. Most of the studies reported in the literature present a short follow-up period, and in some cases, follow-up procedures are not performed. In the present study, it was observed that most of the failure cases in endodontic treatment occurred from 7 to 12 months after the beginning of the treatment. If the follow-up period adopted by the present study were 6 months, for instance, the success rates of the UFSC protocol would surely be higher, although they would not reflect the longer-term success rate.

Survival analysis can also confirm that trauma recurrence may be considered an interference factor in endodontic treatment of traumatized primary teeth. Among the failures verified in this study, half of them occurred in the tooth with trauma recurrence.

Although it is not commonly used in dental research, survival analysis is frequently used in the area of medicine. Its use as a statistical test requires follow-up procedures for treated cases, which may be the explanation for the low number of studies using this type of analysis. Survival analysis, through follow-up of the treated cases, allows assessment of the proposed treatment.

The follow up of any healing treatment, including endodontic treatment, is vital to determine to what extent the technique used offers benefits to the patient. As environmental endodontic treatment has as its goal the maintenance of the traumatized tooth in the buccal cavity until the eruption of the succeeding permanent tooth (17), follow-up procedures must be performed until this period. The maintenance of the tooth in the buccal cavity for a period of time shorter than the primary tooth biological cycle indicates the failure of the treatment. Therefore, no matter which technique or protocol may be chosen for the treatment of traumatized primary teeth, the follow-up procedures must be part of a clinical and radiological approach determined by a pre-established protocol (49).

Conclusions

1 Trauma recurrence in the same tooth is a factor that interferes with the success of endodontic treatment of traumatized primary teeth.

2 Endodontic treatment in traumatized primary teeth, performed according to the UFSC protocol, presents success rates that confirm its clinical applicability.

Acknowledgement – The authors wish to thank Professor Maria Cristina Calvo (PhD) and Professor Sérgio Torres de Freitas (PhD) for their help with the statistical analysis of the data.

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