Pulp survival of permanent teeth following crown fractures - A prospective cohort study

Lokuappu Kuttige Nadeesha Premathilaka[*], Sivaguru Vasantha[**], Lekamalage Hansamali Prasangika [***]

[*] (BDS, MD in Restorative Dentistry)- Senior Registrar in Restorative Dentistry, National Dental Hospital – Colombo, Sri Lanka
[**] (BDS, MS in Restorative Dentistry) – Consultant in Restorative Dentistry, National Dental Hospital – Colombo, Sri Lanka
[***] (BSc (Honors in Statistics))- Temporary Lecturer, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka

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Abstract- Background/ Aim: Preservation of pulp vitality in fractured teeth is important especially in young permanent teeth. The aim of this study was to analyze the pulp survival of permanent teeth following crown fractures. ***Materials and Methods:*** All the patients presented to the Restorative Unit 'A', National Dental Hospital, Colombo, Sri Lanka from June 2016 to December 2017, fulfilling the inclusion criteria were included for the study. Treated teeth were monitored for a period of 12 months from the trauma. Kaplan-Meier method was used to assess the incidence: rate ratio. Log-rank test was applied to assess the differences in the survival rate. Cox proportional hazard regression analysis was performed to investigate the association between pulp survival and the predictor variables. ***Results:*** 83.4% teeth (378/453) showed no loss of pulp vitality. after one year of the injury. The highest pulp survival was observed in uncomplicated crown fractures without a periodontal injury (98.1%). Presence of a concurrent periodontal injury was identified as a highly significant risk factor for pulp necrosis (p value= <2e-16). Level of root maturity and time elapsed since the injury did not show a significant association with pulp survival. ***Conclusions:*** The treatment of crown fractures in the permanent dentition resulted mostly in successful outcomes. Presence of a concurrent periodontal injury was identified as a highly significant risk factor for pulp necrosis.

Index Terms- Crown fracture, permanent teeth, pulp survival, dental trauma

I. Introduction

Dental trauma is one of the most common oral health problems in the general population [1]. Trauma to the permanent dentition can occur in all stages of life, with increased numbers documented in the first and second decades of life [2, 3]. The commonest form of traumatic dental injury to the permanent dentition is crown fracture and constitutes 26% to 76% of all traumatic injuries [4].

According to the International Classification of Diseases (ICD-11) endorsed by the World Health Organization, crown fractures include enamel infraction, enamel fracture, enamel - dentine fracture and complicated crown fracture [5].

Any form of crown fracture should be treated to preserve the pulp vitality, to achieve optimum aesthetic and functional outcome. Preservation of pulp vitality is of major importance especially in young permanent teeth, as maintenance of a healthy pulp throughout the root canal system is important to ensure apexogenesis [6].

The highest pulp survival rate was documented in teeth with uncomplicated fractures without a concurrent periodontal injury [7, 8, 9].

Literature suggests that the stage of root development [6,7,8,10]; presence of a concurrent periodontal injury [6,9]; time interval between trauma and the emergency treatment [11]; type of crown fracture and positive response to pulp sensibility tests at the time of injury[12] are significantly influential on the pulp survival of crown fractured teeth. Nevertheless, some studies have reported that the time interval between trauma and emergency treatment [6,8] and the type of emergency treatment provided [4,10] have no significant effect on pulp survival of the affected tooth.

The aims of this study were to analyze the pulp survival and the factors affecting pulp survival of permanent teeth with crown fractures, presented to Restorative Unit A, National Dental Hospital - Colombo during June 2016 to December 2017.

II. Materials and Methods

This prospective cohort study was conducted at the Restorative Unit A, National Dental Hospital, Colombo, Sri Lanka in the period from June 2016 to December 2018. Ethical clearance was obtained from the Ethical review committee of the Faculty of Medicine, University of Colombo.

All the patients who presented or referred to the unit from June 2016 to December 2017 with a crown fracture in the permanent teeth, within a month of the injury were included in this study after obtaining their informed consent. Patients who had root fractures, intrusion / extrusion / avulsion of the same tooth; a previous history of dental trauma; severe tooth substance loss due to dental caries or tooth wear; root canal treatment in the affected tooth; incomplete data on initial examination /emergency

treatment received; where the emergency care was not in line with the guidelines given by the International Association of Dental Traumatology [13]; dislodged emergency restorations were excluded from the study.

A pre-tested, interviewer-administered, structured compilation sheet was used for data collection. It consisted of questions to elicit demographic data, time elapsed since trauma to the initial treatment, type of emergency treatment received. Clinical examination findings (type of fracture, tooth colour, type of the concurrent periodontal injury if present, restorations placed to treat the fracture), pulp sensibility test results, radiographic findings of the first visit and the follow-up visits were also included in the data collection sheet.

Fractured teeth were treated according to the guidelines given by the International Association of Dental Traumatology[13] by well-trained Dental Surgeons worked at the Restorative Unit A, National Dental Hospital, Colombo. All diagnostic and therapeutic information was consistently recorded during patient management on a separate case record sheet.

Treated teeth were monitored for a period of minimum 12 months after the trauma. Initial follow-up was done 6-8 weeks after the trauma, followed by 3 months, 6 months, 9 months, and 12 months from the trauma. Where there was a concomitant periodontal injury (concussion/ subluxation/ luxation), follow-up was done after 2 weeks, 4 weeks, 6-8 weeks, 3 months, 6 months, 9 months, and 12 months from the trauma.

The whole data set was initially transferred into a Microsoft Excel sheet. The descriptive analysis was done using Microsoft Excel and the statistical software SPSS version 21. Explorative statistical analysis was performed using R software. Kaplan-Meier method was used to assess the incidence: rate ratio. A tooth with two or more of the classical signs of pulp necrosis (i.e., grey/blue/red discoloration of crown, persistent tenderness to percussion, negative sensibility testing after 3 months of shock period, apical radiolucency) was considered as non-vital. Differences in the survival rate were assessed by applying the Log-rank test. Cox proportional hazard regression analysis was performed to investigate the association between pulp survival of traumatized teeth and the predictor variables.

Results

A total of 263 patients were included in this study, of which 224 (85.17%) were males and 39 (14.83%) were females. The mean age of the sample was 16.1 years, with a range of 7 - 62 years.

Of this study sample, 166 patients (63.1%) were referred from the Outpatient Department or Emergency Unit of National Dental Hospital Colombo; 10 (3.8%) were referred from the Oral and Maxillofacial Units of the same hospital and 87 (33.1%) were referred from peripheral hospitals or private dental practices or school dental clinics. On presentation, only 31.1% of teeth had received the emergency treatment for the fractured teeth.

A total number of 453 fractured permanent teeth were evaluated in this study. 74.4% (n= 337) of them had uncomplicated crown fractures and 25.6% (n= 116) had complicated crown fractures. Out of those 337 teeth with uncomplicated crown fractures, 3% had enamel infraction, 10.81% had enamel fracture and the great majority, 60% had enamel-dentine fracture.

131 (28.9%) teeth showed incomplete root formation, while 322 (71.1%) teeth had closed roots.

Out of 453 teeth, 175 (38.6%) were associated with a concomitant periodontal injury. The most common type of periodontal injury was concussion (68%), followed by subluxation (30.9%) and lateral luxation (1.1%) (Table 01).

Of all 263 patients, 121 patients (209 teeth) had received emergency treatment within 2-3 hours of injury, 60 patients (113 teeth) had received it within 3-24 hours of injury and 82 patients (131 teeth) had received it after 24 hours of trauma.

Out of the 337 teeth with uncomplicated crown fractures, 29.4% had received a light cured composite restoration/ reattachment of the fractured fragment; 66.2% had received a GIC restoration initially and a composite restoration on a subsequent visit and 4.4% had received no restoration. Whereas of 116 teeth with complicated crown fractures, the majority (59.5%) were treated with direct pulp capping with Dycal® (Dentsply Caulk); 37.1% were treated with partial/total pulpotomy using non-setting Calcium hydroxide and 3.4% had received root canal treatment (Table 02).

No loss of pulp vitality was observed in 378 teeth (83.4%), after one year of the injury. Uncomplicated crown fractures without a periodontal injury showed the highest pulp survival (98.1%) followed by the uncomplicated crown fractures with a concurrent periodontal injury (84.3%), complicated crown fractures without a periodontal injury (62.9%) and complicated crown fractures with a concurrent periodontal injury (46.3%) respectively (Table 02).

The Kaplan-Meier curves which illustrate the pulp survival probability over a period of 12 months in relation to the type of crown fracture, concurrent periodontal injury, root maturity, duration between trauma and the emergency treatment; and the type of treatment provided are generated (Figures 1-5).

Figure 01: The Kaplan-Meier curve which illustrates the pulp survival probability in relation to the type of crown fracture. P-value for the log rank test is <0.0001.

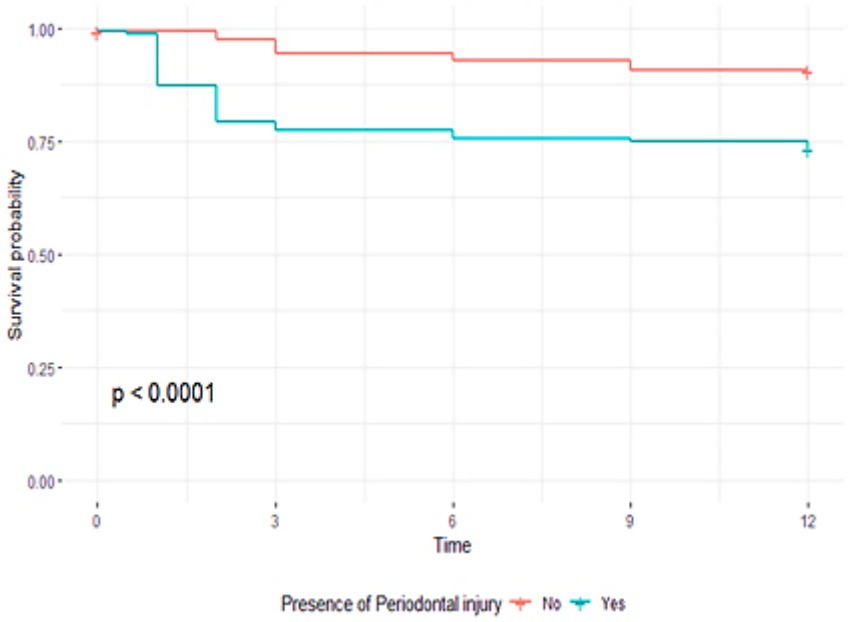


Figure 02: The Kaplan-Meier curve which illustrates the pulp survival probability in relation to the presence/absence of a concurrent periodontal injury. P-value for the log rank test is <0.0001.

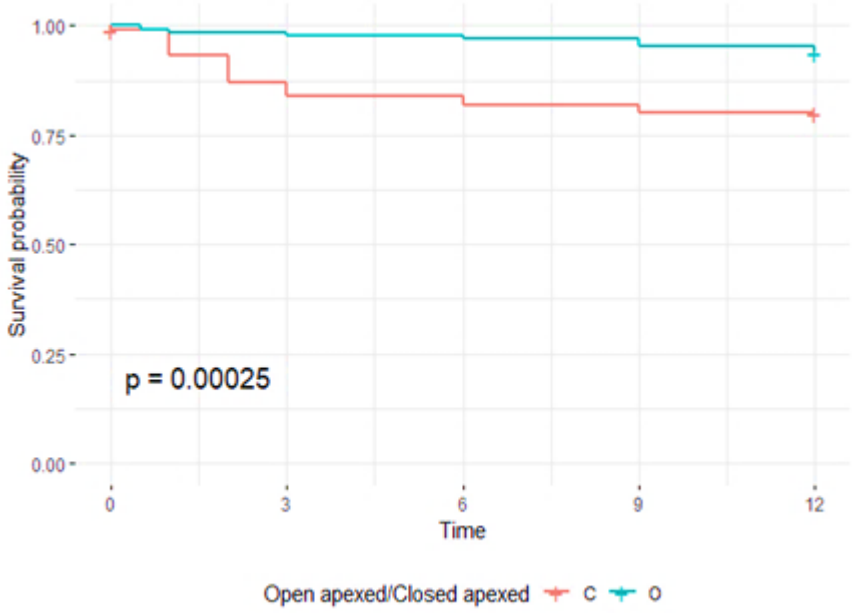


Figure 03: The Kaplan-Meier curve which illustrates the pulp survival probability in relation to the level of root maturity. P-value for the log rank test is <0.00025.

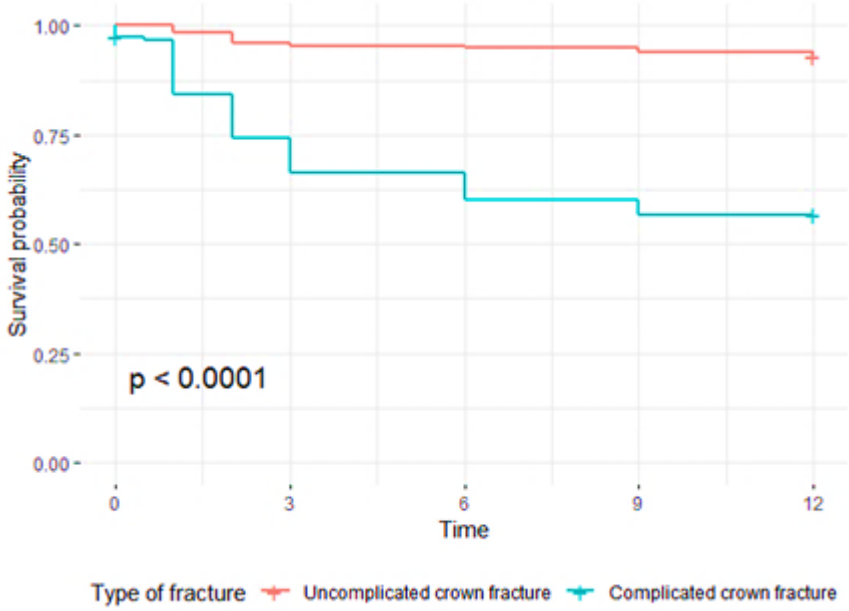
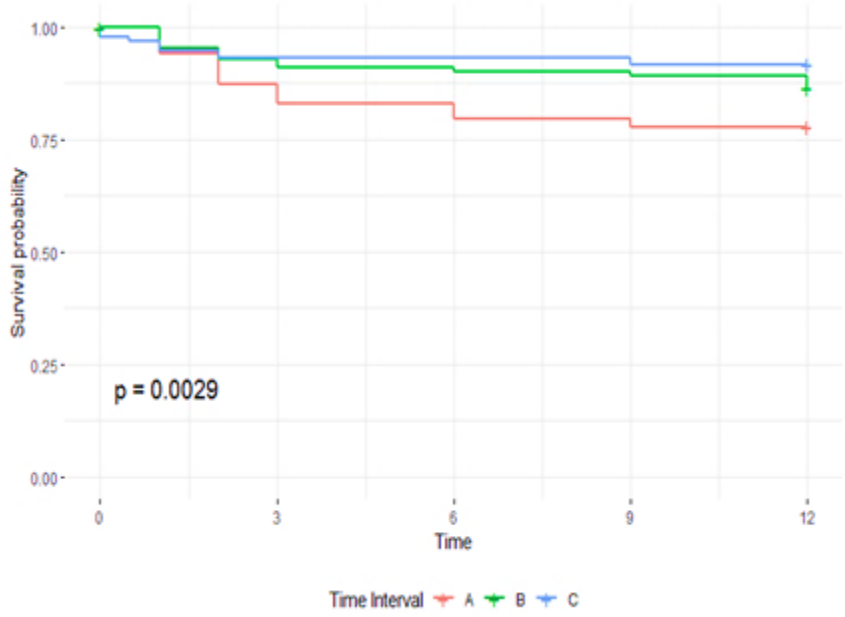
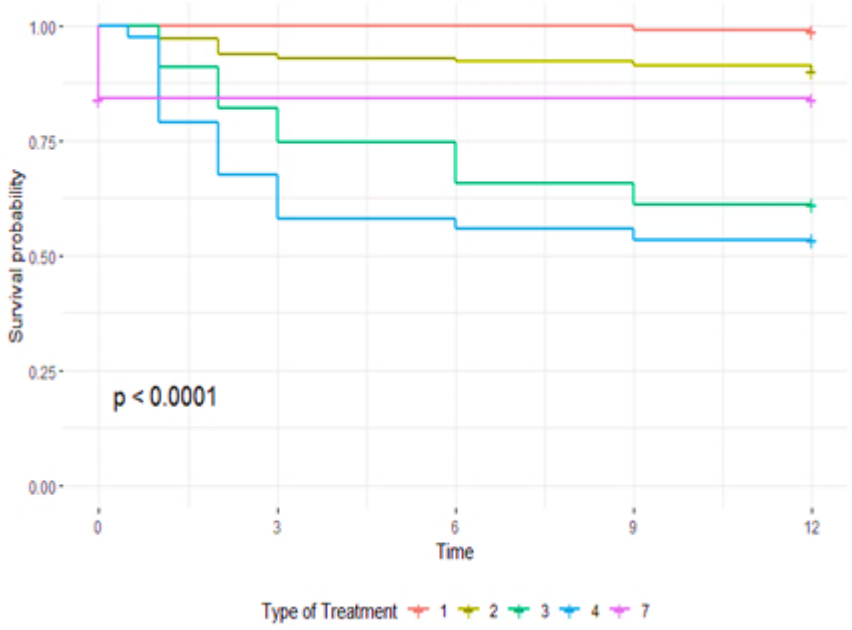


Figure 04: The Kaplan-Meier curve which illustrates the pulp survival probability in relation to the duration between trauma and the emergency treatment. P-value for the log rank test is <0.0029.



A- Emergency treatment is received within 2-3 hours of injury, B- Emergency treatment is received within 3-24 hours of injury, C- Emergency treatment is received after 24 hours of injury

Figure 05: The Kaplan-Meier curve which illustrates the pulp survival probability in relation to the type of restorative treatment. P-value for the log rank test is <0.0001.



1- Reattachment of the fractured fragment or composite restoration, 2- Initial GIC restoration followed by a composite restoration, 3- Direct pulp capping, 4- Partial/ total pulpotomy, 7- Any other treatment

Cox proportional hazard regression analysis was applied to investigate the association between the pulp survival and the prognostic factors. However, as proportional hazard assumptions were not met, the extended Cox model was used. Formation of the Extended Cox model was done by adding the time function to the variable 'presence of a periodontal injury' (as presence of a periodontal injury is the variable which did not meet the PH assumption). Finally, the best model was selected by stepwise variable selection method and the results are given in Table 03. Accordingly, presence of a concurrent periodontal injury was identified as a highly significant risk factor for pulp necrosis in crown fractured teeth (p value= <2e-16).

Discussion

This prospective cohort study aimed to assess the pulp survival of permanent teeth following crown fractures and to determine the impact of different prognostic factors on pulp survival.

In the present study, most of the teeth showed uncomplicated crown fractures (74.4%) as reported in many other studies [9,10,14].

According to the study findings, 83.4% of crown fractured teeth were vital after one year of the injury as reported in another study [9]. In accordance with similar other studies [9,10], the highest pulp survival was observed in the group of uncomplicated crown fractures without a periodontal injury (98.1%). Pulp survival in the group of uncomplicated crown fractures with a concurrent periodontal injury was 84.3% and this finding is almost similar or above the findings of other studies [9,10].

In this study, pulp survival of complicated crown fractures without a periodontal injury was 62.9%. Whereas a higher survival rate of 86.1% was observed in another study [9]. The pulp survival of complicated crown fractures with a concurrent periodontal injury was as low as 46.3%. The same finding has been reported in another study [10].

In the literature it has been reported that the stage of root development [6,7,8,10]; presence of a concurrent periodontal injury [6,9]; time elapsed since the trauma [11]; type of the crown fracture and response to pulp sensibility tests at the time of injury [12] are significantly influential on the pulp survival of crown fractured teeth.

Kaplan-Meier curves were generated (Figures 01, 02, 03, 04 and 05) and the differences in the survival rates were assessed by the Log-rank test. According to that, pulp survival probability of the complicated crown fractures was significantly lower than that of the uncomplicated crown fractures (p= <0.0001). In accordance with the other studies [6,9], a significantly low probability of pulp survival was observed in the teeth associated with a concurrent periodontal injury (p= <0.0001). Further, a significantly low probability of pulp survival was observed in the teeth with closed apices than the teeth with open apices (p= <0.00025) as found in another study[8]. Interestingly, a low pulp survival probability was observed in teeth which had received the emergency treatment within 2-3 hours of the injury compared to the groups of teeth which had received the emergency care after 3- 24 hours and after 24 hours (p= 0.0029). This might be explained by the fact that most of the teeth which received treatment within 2-3 hours had complicated crown fractures, in which pulp survival probability was low.

Moreover, the teeth treated with reattachment/ composite restoration showed the highest pulp survival probability, while the teeth treated by initial GIC+ composite restoration, any other

treatmentin, direct pulp capping and pulpotomy showed low of pulp survival probabilities respectively (p= 0.0001).

Cox proportional hazard regression analysis was applied to investigate the association between the pulp survival and the prognostic factors. However, as proportional hazard assumptions were not met the extended Cox model was used, and the stepwise variable selection method was used to select the best model (Table 03). Accordingly, presence of a concurrent periodontal injury was identified as a statistically highly significant risk factor (p= <2e-16) for pulp necrosis in crown fractured teeth. This finding is in line with other studies [6,9]. This increased risk of pulp necrosis may be due to the temporary or permanent interruption of the blood supply at the apical foramen, which is typically linked to luxation injuries. In contrast to other studies [8,10], level of root maturity did not show a significant association with pulp survival (p= 0.93). Further, direct pulp capping (p= 0.008) and pulpotomy (p= 0.004) treatments were found to have significant associations with pulp necrosis. In the present study, no significant association between the time elapsed since the injury to emergency care and pulp necrosis was identified.

The key factor which determines the prognosis of a tooth after any form of pulp exposure is the elimination of the bacteria invading the pulp [15, 16]. Therefore, removal of the infected pulp tissue as early as possible following the injury and provision of a hermetic seal to the exposed pulp is critical in management [11, 16]. Several procedures have been recommended for the treatment of exposed pulps and these include direct pulp capping, partial pulpotomy, total cervical pulpotomy and pulpectomy procedures [10]. Pulpotomy procedures appear to be superior to pulp capping [10, 16].

In the present study, the majority (59.5%) of pulp exposed teeth were treated with direct pulp capping and 37.1% were treated with partial/total pulpotomy (Table 02). The frequency of pulp necrosis among the teeth treated with direct pulp capping was 40.6%. Hecova et al.[7] has observed a similar rate of pulp necrosis and infection (45.5%) in teeth treated with direct pulp capping. The frequency of pulp necrosis in pulpotomy treatment was slightly higher (46.5%) than that of the direct pulp capping. Whereas many other studies have reported a lower rate of pulp necrosis following the pulpotomy treatment compared to the direct pulp capping [7,8,9].

The indication for a partial pulpotomy is judged by the clinical assessment of bleeding from the pulp, which should be controlled within 3 to 5 minutes under the slight pressure of a cotton pellet soaked in physiologic saline[17]. If bleeding is excessive, a more invasive procedure such as total coronal pulpotomy may be needed[18]. In the present study, patients who were referred to the clinic after the pulpotomy treatment fulfilling the inclusion criteria were included. Therefore, the variability in clinical judgement of bleeding from the pulp, which is a limitation of this study would have contributed to the observed higher frequency of pulp necrosis after the pulpotomy.

Further to that, in other studies, either MTA or Calcium hydroxide was used as the medicament in pulpotomy. Whereas in this study, the only medicament used was Calcium hydroxide as it was the material available in the clinic free of cost. In the literature, it has been reported that the clinical outcome of MTA is better than Calcium hydroxide in the case of indicated pulpotomies[9]. This may also have contributed to the relatively higher rate of pulp necrosis observed in pulpotomies in the present study.

In conclusion, the highest pulp survival was observed in teeth with uncomplicated crown fractures which did not have a concurrent periodontal injury and the lowest pulp survival was observed in complicated crown fractures which had a concurrent periodontal injury. The presence of a concurrent periodontal injury was identified as a statistically highly significant risk factor for pulp necrosis in crown fractured teeth. Level of root maturity and time elapsed since trauma to the emergency care did not show significant association to the pulp survival.

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AUTHORS

First Author – Lokuappu Kuttige Nadeesha Premathilaka (BDS, MD in Restorative Dentistry)- Senior Registrar in Restorative Dentistry, National Dental Hospital – Colombo, Sri Lanka (Currently, attached to the Faculty of Dental Sciences, University of Peradeniya)

Second Author – Sivaguru Vasantha (BDS, MS in Restorative Dentistry) – Consultant in Restorative Dentistry, National Dental Hospital – Colombo, Sri Lanka

Third Author – Lekamalage Hansamali Prasangika (BSc (Honors in Statistics))- Temporary Lecturer, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka

Correspondence Author – L.K.N. Premathilaka, Address- Division of Pediatric Dentistry, Dept of Community Dental Health, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka, E-mail- nadeeshap@dental.pdn.ac.lk, Telephone: +94704298103