# Determining Treatibility of Primary Teeth with Pulpal Exposure

Doğan S* / Durutürk L** / Orhan A I*** / Batmaz I****

***Objectives***: *To determine rates of pulpal exposure during caries removal with an excavator or a bur, to assess success rates of vital pulp therapies in both cases, to analyze pulpal bleeding as an indicator of primary teeth treatability.* ***Study Design***: *Of the 352 primary mandibular molars with deep carious lesions, 141 with pulp exposed during the removal of caries were grouped according to type of instrument causing pulpal exposure and existence of bleeding at the exposure site. Teeth suitable for direct pulp capping or formocresol pulpotomy were treated and followed up for two years.* ***Results***: *The difference between the rates of pulpal exposure with an excavator (52.5%) or a bur (47.5%) was insignificant. The treatment success rate of teeth with pulp exposed by an excavator (15.8%) was significantly lower than teeth with pulp exposed by a bur (48.8%), regardless of whether bleeding existed at the exposure site or not; however, when bleeding existed, this difference was insignificant (15.8% and 40.6%, respectively).* ***Conclusions***: *Pulpal exposure possibility during caries removal caused by an excavator and a bur was similar, the treatment success rate was lower when the exposure was caused by an excavator, the existence of pulpal bleeding resulted in mistakes in diagnoses.*

***Keywords***: *Deciduous teeth, Primary teeth, Deep carious lesion Mechanical pulp exposure Carious pulp exposure,.*

## INTRODUCTION

Unfavorable dietary habits, inadequate oral hygiene training dental care, and limited access to preventive dental treatment are factors that may result in the development of deep caries lesions in children. Radiographically, many of these lesions appear to be very close to or actually involve the dental pulp. In order to reach an intelligent decision regarding the treatment of teeth with deep caries that extend to the pulp, accurate evaluation of pulp status is essential. In cases where exposure is observed during caries removal, both the size of the exposure site and the nature of the bleeding must be carefully examined to correctly diagnose pulp status.[1-6] Focusing only on bleeding characteristics is known to be unreliable, resulting in 30-40% fallibility in clinical diagnosis of the histological status of pulp in primary teeth with deep carious lesions.[7] For this reason, it has been asserted that clinical criteria may only form the basis of decisions related to pulp 'treatability' by vital pulp therapy.[7-9]

* Salih Doğan, DDS. PhD, Department of Pedodontics School of Dentistry, Erciyes University, Kayseri, Turkey
** Leyla Durutürk, Professor, Department of Pedodontics School of Dentistry, Ankara University, Ankara, Turkey.
*** Ayşe Işıl Orhan, DDS. PhD. Ayşe ,Ministry of Health, Ankara Oral and Dental Health Center, Ankara, Turkey.
**** İnci Batmaz, Assoc. Professor Department of Statistics, Middle East Technical University, Ankara, Turkey.

Send all correspondence to: Professor Leyla Duruturk, Ankara University Faculty of Dentistry, Department of Pedodontics, Besevler 06500, Ankara- Turkey

Phone: +90 312 296 5662
Fax: +90 312 212 39 54

E- mail: salihdogan@erciyes.edu.tr
dtsalih@gmail.com

Emphasis has been placed on the need to determine the nature of pulpal exposure – either mechanical or carious – in order to determine pulpal status. This critical evaluation must be made in the process of removing the final bit of caries that immediately overly or involve the pulp.[1] However, it is possible for a thin, demineralized layer of dentin covering the pulp tissue to be unnoticeably perforated during caries removal, thus complicating the determination of pulpal status. In order to correctly evaluate the relationship between the pulp and the carious lesion, careful removal of the necrotic and infected layer of dentin adjacent to the pulp is recommended.[1,5] From this perspective, knowledge as to which type of instrument provides the safest means of removing deep caries lesions takes on greater importance. Some authors advocate the use of a large, round bur as the best method for removing caries, since a spoon excavator may cause exposure during the removal process.[6] On the contrary, others believe that instrument type is of minor consideration and that both burs and excavators can be used successfully.[1,3,10]

In light of the above information, the aims of this study were to determine the rates of pulpal exposure during the removal of deep carious lesions in primary teeth using a slow-speed round steel bur vs. an excavator, to evaluate the treatment success rates among teeth in which pulpal exposure occurred during the removal of caries with a bur vs. an excavator and to analyse the relationship between bleeding characteristics of pulpal tissue and decisions related to treatability of primary teeth with deep carious lesions.

## MATERIAL AND METHOD

The study was conducted on 352 primary mandibular molars with deep carious lesions in 270 children aged 6-9 years with no history of systemic illness who attended the Pedodontics Clinic at the Ankara University Faculty of Dentistry. Parents/guardians of all participating children gave their written informed consent, and the study was reviewed and approved by the Ankara University Faculty of Dentistry Ethics Committee (report No: 83).

Teeth were selected according to the following criteria:

**Clinical criteria**: Absence of spontaneous or persistent pain, absence of any soft tissue swelling or signs of sinus formation, absence of tenderness to percussion and palpation, absence of pathological or physiological tooth mobility and the possibility of proper tooth restoration.

**Radiographic criteria:** Deep carious lesions approximating but not involving the pulp, absence of internal root resorption, absence of apical or furcal radiolucency and pathological external root resorption, root resorption not exceeding 1/3 root length, absence of intra-canal calcification.[2,6-9]

**Examiner calibration**: Clinical and radiographic evaluations of 35 randomly selected children with teeth with deep carious lesions were conducted pre-operatively by two examiners (S.D and A.I.O) calibrated for diagnosis and treatment criteria. Following indication, all treatment was performed by the same examiner (S.D). At each recall period, all teeth were clinically and radiographically re-evaluated by both examiners without knowledge of the group to which the assessed teeth belonged. Evaluations were recorded by consensus, or, if the examiners disagreed, the poorest assessment was recorded. Re-evaluation of 10 percent of all radiographs demonstrated intra-examiner reliability.

Following isolation with rubber dam, all gross caries were carefully peeled out using a spoon excavator in order to avoid unnecessary pulpal exposure; however, in spite of this, 74 out of 352 teeth were clinically exposed during the procedure. Among them, teeth identified as having inflamed or necrotic pulp based on the condition of the exposure site and the nature of the bleeding underwent pulpectomies and were excluded from further evaluation, whereas teeth considered to be suitable candidates for pulpotomy were included in the study. For these teeth, pulpotomy procedures were performed following the removal of the remaining caries.

The remaining unexposed 278 teeth were anesthetized, and all caries were removed using a sterile, round steel bur in a slow-speed handpiece. Necrotic and infected dentine chips were washed out with saline, and the final soft carious dentine immediately overlying the pulp were removed.

During this process, 67 teeth were exposed, either inadvertently or cariously. Of these, 23 teeth were treated by direct pulp capping and 30 by formocresol pulpotomy. Choice of treatment was based on the following criteria:

1. **Direct pulp capping: a)** pin-point, mechanical exposure of the pulp **b)** little or no bleeding at the exposure site.[2,5-7,11-14]
2. **Pulpotomy: a)** larger than pin-point mechanical exposure of the pulp, or mechanical exposure of the pulp at multiple sites **b)** carious exposure of the pulp (regardless of exposure size) **c)** light red blood at the exposure site or the canal orifices, the flow of which may be easily arrested within 5 min..[1-7,15-17]

Restorations were completed during the same visit using zinc oxide-eugenol cement as a base material and silver amalgam.

Of the 352 teeth initially included in the study, 141 were judged to have suffered from pulpal exposure. These teeth were grouped first by type of instrumentation causing pulpal exposure and then by bleeding at the exposure site (Figure 1).

Teeth in both groups were identified as having either healthy, inflamed or necrotic pulp acording to the appearance and bleeding characteristics of pulpal tissue, as follows:

**Healthy pulp**: little or no bleeding, evidence of red pulp tissue inside the pulp exposure.

**Inflamed (irreversible) pulp**: "excessive" bleeding and deep red blood at the exposure site or canal orifices

**Necrotic pulp**: no visible tissue or fluid whatsoever [1-7, 11,13,14,18]

Teeth that were found suitable for vital pulp therapy (direct pulp capping or pulpotomy) were described as 'treatable', whereas teeth with inflamed or necrotic pulp were described as 'untreatable'.[1-3, 5-7,11,13,14,19-22]

In both Groups A and B, although some teeth were initially diagnosed as inflamed based on the characteristics of bleeding at the exposure site, the characteristics of bleeding from the canal orifices subsequently suggested the radicular pulp to be healthy; therefore, these teeth were treated by pulpotomy and were included in the evaluation process. Conversely, some teeth that were initially diagnosed as candidates for pulpotomy based on the characteristics of bleeding from the exposure site were subsequently determined to have inflamed or necrotic radicular pulp; therefore, these teeth were treated by pulpectomy and were excluded from the evaluation process.

All teeth were clinically and radiographically evaluated at 3, 6, 18 and 24 months after treatment. Treatment was assessed as successful based on the absence of the following: spontaneous pain or pain initiated by stimuli, soft-tissue swelling or signs of sinus formation, mobility, tenderness to percussion, signs of defective restoration or recurring caries, visible periapical or furcal radiolucency, radiographic evidence of pathological internal or external root resorption.[2,6,16,17,23-27]

## Statistical analysis

İntra-group analysis was performed using paired McNemar chi-square

test and independent chi-square test was used for inter-group comparisons. Yate's correction was used when necessary. The level of probability set for statistical significance was 5%. The statistical software R-2.12.0 (www.R-project.org) was used in the statistical analysis.

# RESULTS

Kappa Tests indicated good inter-examiner (0.78) and very good intra-examiner (0.85) reliability.

Pulpal exposure was observed in 141 of 352 teeth with deep carious lesions (39%). Of these, 74 (52.5%) were exposed during the removal of caries with an excavator and 67 (47.5%) were exposed with a bur. No statistically significant differences in exposure rates were found between the groups ($p>0.05$).

## Intra-group Evaluation

**Group A:** Teeth with pulpal exposure from caries removal with an excavator (74 teeth)

**Group A-1:** No bleeding at exposure site (10 teeth)

The finding of no bleeding and no evidence of vital pulp tissue at the exposure site in all the teeth in Group A-1 appeared to indicate necrotic coronal pulp. However, in two cases, bleeding

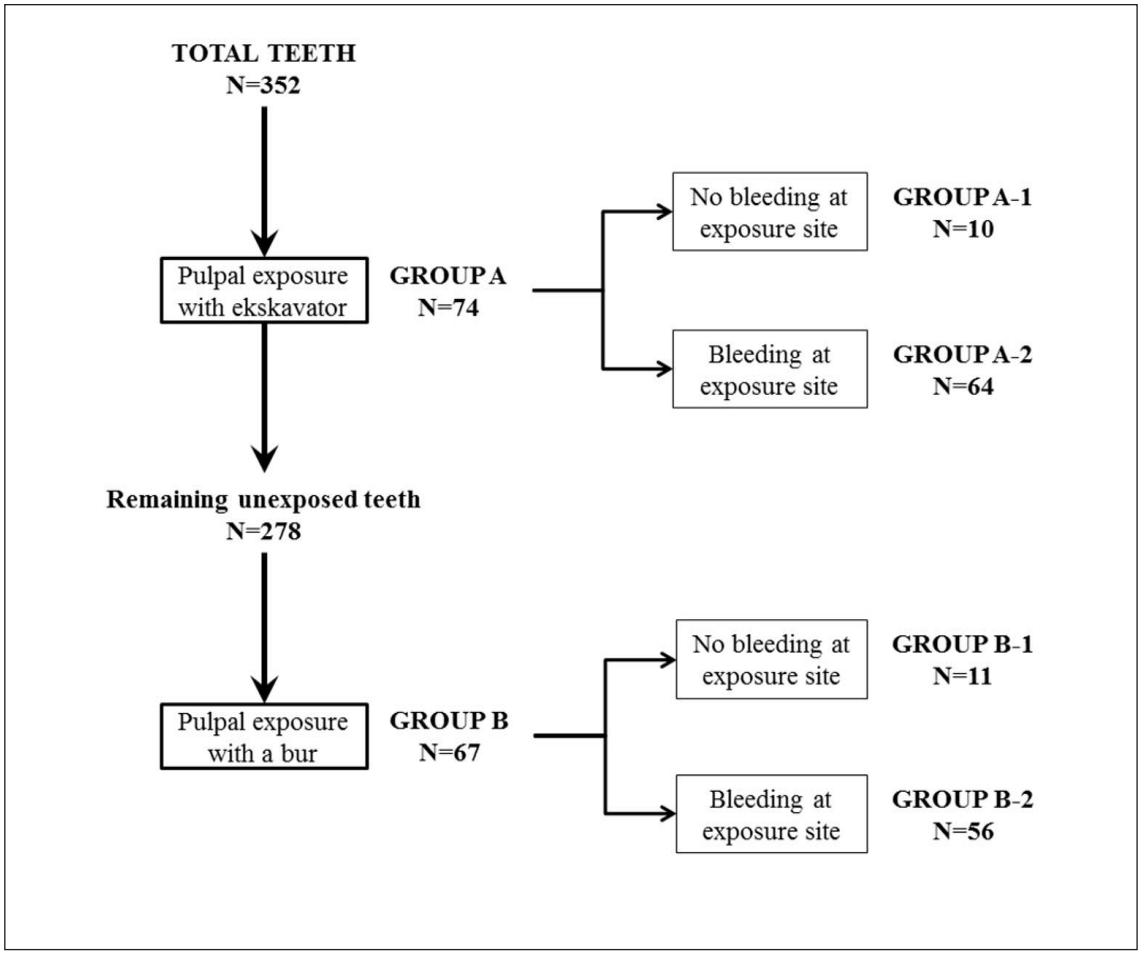


**Figure 1**: Groups by type of instrument and bleeding existence

was observed at the canal orifices. Ultimately, pulpectomies were performed on these teeth as well, because bleeding characteristics indicated inflamed radicular pulp.

**Group A-2**: Bleeding at exposure site (64 teeth)

Based on bleeding characteristics at the exposure site, 41 (65%) out of 64 teeth in Group A-2 were judged to be suitable candidates for pulpotomy. However, based on bleeding from the canal orifices following coronal pulp amputation, only 25 of these teeth (61%) were judged to be 'treatable' by pulpotomy. In the remaining 16 teeth, bleeding characteristics at the pulpal orifice indicated inflamed radicular pulp, and pulpectomies were performed on these teeth. At the end of a 2-year follow-up period, treatment was defined as successful in only 3 (15.8%) out of 19 teeth in Group A-2. Six teeth were not assessed due to the failure of patients to return for recall examination. The difference between the number of teeth assessed as 'treatable' (n=25, 61%) and the number in which treatment was assessed as successful (n=3; 15.8%) was statistically significant ($p<0.05$) (Table 1).

Based on bleeding characteristics at the exposure site, 23 teeth in Group A-2 were judged to be "untreatable" due to inflamed pulp. However, based on bleeding from the canal orifices, seven of these teeth were judged to be 'treatable' by pulpotomy, and pulpotomies were performed accordingly. However, at the end of a 2-year follow-up period, treatment was defined as unsuccessful in four pulpotomized teeth in this group. Three teeth were not assessed due to failure of patients to return for recall examination (Table 2).

**Group B**: Teeth with pulpal exposure from caries subsequent complete caries removal with a slow-speed round steel bur (67 teeth)

**Group B-1**: No bleeding at exposure site (11 teeth)

The finding of no bleeding and evidence of red pulpal tissue at the exposure site in all teeth (11 teeth) in Group B-1 appeared to indicate healthy coronal pulp. Of these, seven (63.6%) were treated by direct pulp capping and four (36.4%) by formocresol pulpotomy, in accordance with the treatment criteria described above. At the end of a 2- year follow-up period, treatment was defined as successful in only 7 (77.8%) out of 9 treated teeth in Group B-1. Two teeth were not assessed due to failure of patients to return for recall examination . The difference between the number of teeth assessed as 'treatable' (n=11, 100%) and the number in which treatment was assessed as successful (n=7, 77.8%) was statistically insignificant ($p>0.05$) (Table 1).

**Group B-2**: Bleeding at the exposure site (56 teeth)

Based on the characteristics of bleeding at the exposure site, 49 (87.5%) out of 56 teeth in Group B-2 were judged to be candidates for vital pulp therapy. Of these, 16 (32.7%) were treated by direct pulp capping and 26 (53%) by formocresol pulpotomy (42 teeth (85.7%), in total), in accordance with the treatment criteria described above; however, in the remaining seven teeth, bleeding characteristics

**Table 1:** Treatment success rates at the end of a 2-year follow-up period for all groups

| GROUPS N = 141 | Bleeding existence | Candidate for vital pulp therapy | Treatable | | Total Treatable Teeth | Attained | Total success |
|---|---|---|---|---|---|---|---|
| | | | Direct pulp capping | Pulpotomy | | | |
| GROUP A Exposed with excavator N = 74 (%52,5) | Group A – 1 Bleeding (-) N = 10 | - | - | - | - | - | |
| | Group A – 2 Bleeding (+) N = 64 | 41 | - | 25 | 25 / 41 (%61) | 19 | 3 / 19 (%15.8) |
| TOTAL | N = 74 | 41 | - | 25 | 25 / 41 (%61) | 19 | 3 / 19 (%15.8) |
| GROUP B Exposed with bur N = 67 (%47,5) | Group B – 1 Bleeding (-) N = 11 | 11 | 7 | 4 | 11 / 11 (%100) | 9 | 7 / 9 (%77.8) |
| | Group B – 2 Bleeding (+) N = 56 | 49 | 16 | 26 | 42 / 49 (%85.7) | 32 | 13 / 32 (%40.6) |
| TOTAL | N = 67 | 60 | 23 | 30 | 53 / 60 (%88.3) | 41 | 20 / 41 (%48.8) |

* $p < 0,05$

following coronal pulp amputation indicated inflamed radicular pulp, and pulpectomies were performed on these teeth. At the end of a 2- year follow-up period, treatment was defined as successful in only 13 (40.6%) out of 32 treated teeth in this group. Ten teeth were not assessed due to the failure of patients to return for recall examination. The difference between the number of teeth assessed as 'treatable' (n=42, 85.7%) and the number in which treatment was assessed as successful (n=13, 40.6%) was statistically significant ($p>0.05$) (Table 1).

The remaining seven teeth in Group B-2 were judged to be 'untreatable' based on the characteristics of bleeding at the exposure site, which appeared to indicate inflamed pulp. However, based on bleeding from the canal orifices, which appeared to indicate healthy radicular pulp, one of these teeth was judged to be 'treatable' by pulpotomy, and a pulpotomy was performed accordingly. However, at the end of a 2-year follow-up period, the treatment of this tooth was judged to be unsuccessful (Table 2).

## Intergroup Evaluation

*By bleeding:*

**Group A-1 and B-1 (no bleeding)**: No bleeding was observed at the exposure site in any of the teeth in Group A-1, all of which were judged to be "untreatable". In contrast, although no bleeding was observed at the exposure site in any of the teeth in Group B-1, all these teeth (100%) were judged to be "treatable"; however, at the end of the follow-up period, the treatment success rate of Group B-1 was found to be 77.8%.

**Group A-2 and B-2 (bleeding):** The difference in the rate of teeth judged to be "treatable" and the rate of treatment success at the end of the follow-up period was statistically significant ($p<0.05$) for both Group A-2 (61%-15.8%) and Group B-2 (85.7%-40.6%). However, there was no statistically significant difference between the treatment success rates at the end of the follow-up period for Group A-2 (15.8%) and Group B-2 (40.6%) ($p>0.05$) (Table 1).

*By instrument type*

Group A and B: Of a total of 41 teeth initially assessed as candidates for pulpotomy in Group A, in which pulp was exposed during caries removal with an excavator, 25 (61%) were judged to be "treatable"; however, at the end of the follow-up period, treatment was evaluated as successful in only three teeth (15.8%). Of a total of 60 teeth initially assessed as candidates for pulpotomy in Group B, in which pulp was exposed during caries removal with a bur, 53 (88.3%) were judged to be "treatable"; however, at the end of the follow-up period, treatment was evaluated as successful in only 20 teeth (48.8%). Accordingly, the difference between the rate of teeth judged to be "treatable" and the treatment success rate at the end of the follow-up period was statistically significant in both Groups A and B ($p<0.05$). Furthermore, the differences between groups in both rates of "treatable" teeth (Group A: 61%; Group B: 88.3%) and treatment success rates (Group A:15.8%; Group B: 48.8%) were also statistically significant ($p<0.05$) (Table 1).

No loss of restoration or secondary caries were observed during the follow-up period.

## DISCUSSION

Since the likelihood of success of any indicated vital pulp therapy is thought to be dependent upon the accurate diagnosis of pulp status,[6,7,11,14,18,26] correct evaluation of exposure size, pulp appearance, quality and quantity of bleeding and cause of exposure (mechanical vs carious) is essential.[1,2,4,5.7,9,13]

The present study found no statistically significant difference between the types of instrument used in removing caries with regard to pulpal exposure rates. However, while the choice of instrument may not affect the likelihood of pulpal exposure, it may affect the ability to correctly assess the treatability of teeth. This study found that the treatment success rate of teeth with pulp exposed by an excavator during caries removal (Group A)(15.8%) was significantly lower than teeth with pulp exposed by a bur (Group B)(48.8%). Based on this finding, it may be suggested that correct assessment the status of the exposure site may be difficult in cases where the

**Table 2:** Treatability of the teeth with inflamed coronal pulp and healthy radicular pulp at the end of a 2-year follow-up period

| GROUPS N = 120 | Inflamed Coronal Pulp | Healthy Radicular Pulp (Treatable) | Attained | Total Success |
|---|---|---|---|---|
| Group A – 2 Bleeding (+) N = 64 | 23 | 7 / 23 | 4 / 7 | 0 |
| Group B – 2 Bleeding (+) N = 56 | 7 | 1 / 7 | 1 / 1 | 0 |
| TOTAL | 30 | 8 / 30 | 5 / 8 | 0 |

lesion is so deep as to result in exposure by an excavator during caries removal. At the same time, a general evaluation of treatment success rates showed statistically significant differences between the rate of teeth judged to be "treatable" and the rate of teeth with successful treatment outcomes, regardless of whether the pulp was exposed by an excavator (Group A) ("treatable", 61%; success rate, 15.8%) or a bur (Group B) ("treatable", 88.3%; success rate, 48.8%). Accordingly, it is possible to talk about mistaken diagnoses in both Groups A and B, which, in view of the direct relationship between caries depth and pulpal pathology,[5,14] may be attributed to the depth of the caries. Although treatability was often incorrectly assessed regardless of the type of instrument causing pulpal exposure, the rate of fallibility was higher in the case of exposure by an excavator than in the case of exposure by a bur, probably as a result of greater difficulties in evaluating the status of the exposure site in the former case. In fact, previous studies have pointed out that correct diagnosis may be particularly difficult in teeth with cariously exposed pulp,[11] since a carious exposure, even of pinpoint size, is accompanied by inflammation.[1,5,6,9]

Differences between the rates of teeth regarded as "treatable" and those treated successfully were also found to be statistically significant in teeth with bleeding at the exposure site, regardless of whether exposure was caused by an excavator (Group A-2) ("treatable", 61%; success rate, 15.8%) or a bur (Group B-2) ("treatable", 85.7%; success rate, 40.6%). In other words, the assessment of treatability based on bleeding characteristics resulted in considerable fallibility in diagnosis. Although the nature of bleeding plays an important role in the evaluation of pulpal status,[1,5,9] there is some controversy regarding the amount of bleeding that is considered acceptable.[28] Accordingly, the differences between the assessments of treatability and the actual treatment outcome in these groups should be considered reasonable. Moreover, no significant differences were also observed between the treatment success rates in Group A-2 (15.8%) and Group B-2 (40.6%). In line with the above discussion, it may be stated that the existence of bleeding contributed to increases in mistaken diagnoses independent of the type of instrument causing the pulpal exposure.

In contrast, in those teeth with no bleeding at the exposure site (Group A-1 and B-1), "treatability" was associated with the type of instrument causing the pulpal exposure. Whereas absence of bleeding in teeth with pulp exposed by an excavator during caries removal (Group A-1) indicated that teeth were "untreatable", absence of bleeding in teeth with pulp exposed by a bur during caries removal (Group B-1) indicated that teeth were, in general, "treatable". Considering the success rate in Group B-1 (77.8%), it can be assumed that teeth in this group had healthy pulp. In fact, it has been stated that teeth with healthy pulp, which are considered favourable candidates for vital pulp therapy, have little or no bleeding.[1,3,5,11] On the other hand, studies have reported that teeth with deep carious lesions but free of any clear evidence of pulpal involvement may result in carious exposure[1] and the pulpal tissue may frequently even undergo necrosis due to the structural characteristics of the dentin in primary teeth,[2,3,11,14] and that necrotic pulp exhibits no bleeding.[3,5,7] Accordingly, in cases where there is no bleeding at the exposure site, but where the carious lesion is deep enough for an excavator to cause pulpal exposure during caries removal, we can assume that exposure is not due to carelessness, but to carious involvement of the pulp that has resulted in necrosis and thus made the tooth "untreatable". In fact, all the teeth in Group A-1 were untreatable.

In this study, of the 30 teeth initially assessed as "untreatable" due to an assumption of pulpal inflammation based on the characteristics of bleeding at the exposure site, pulpotomies were performed on eight when the characteristics of bleeding from the canal orifices suggested that the radicular pulp was healthy. However, in all cases returned for recall examination, treatment was judged unsuccessful at the end of the follow-up period. Numerous studies have emphasized that excessive hemorrhaging at the point of carious exposure is invariably associated with a generalized inflammation of the pulp.[2,5,6] The results of the present study also found that in primary teeth, if the coronal pulp is inflamed, the radicular pulp is also inflamed.

Final restoration plays an important role in the outcome of primary molar pulpotomies, and the literature has reported on a wide variety of materials used for restoration following vital pulp therapy in primary teeth.[10,16,22,23-27] A review study pointed out that despite the fact that SSCs have been the preferred treatment for many years, there remains no clear evidence that shows SSCs to be superior to other types of restoration.[29] For example, amalgam has been reported to be a more appropriate restorative material for posterior primary teeth, especially in cases where it is difficult to obtain tooth isolation and patient cooperation.[30] Amalgam has also been suggested as an appropriate alternative to an SSC for primary teeth with functional life spans of 2 years or less.[12] Financial concerns,[17] adaptation difficulties and problems in choosing the proper size have also been mentioned in connection with SSCs.[31]

## CONCLUSION

This study indicated that there was no statistically significant difference in the rate of pulpal exposure between the types of instrument used in removing caries, treatment success rates were lower in teeth with pulp exposed during caries removal with an excavator in comparison to those with pulp exposed by a bur and bleeding characteristics were not consistently reliable predictors of teeth "treatability" ; however, excessive bleeding at the exposure site was an infallible predictor of "untreatable" teeth, and, in cases where the carious lesion was deep enough for an excavator to cause pulpal exposure during caries removal, absence of bleeding at the exposure site also indicated "untreatable" teeth.

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