A Retrospective Study for Prediction of Factors Affecting Survival of Primary Molars Following Pulpotomy with Mineral Trioxide Aggregate

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감사의 글

이 논문이 나올 때까지 도와주신 모든 분들께 감사 드립니다.

먼저 바쁘고 힘든 병원에서 열정과 애정으로 지도해주신 최형준 교수님께 진심으로 감사드립니다.

또 논문을 심사해주시고 조언을 아끼지 않아주신 김성오 교수님과 강정민 교수님께도 감사드립니다.

늘 따뜻한 사랑을 아끼지 않는 아버지, 어머니, 그리고 가족들에게도 감사의 말을 전합니다. 또 행복하고 즐거운 수련생활을 할 수 있도록 항상 응원해주고 기쁨과 고민을 나누는 의국 선후배들, 특별히 동기인 권우진, 김치훈, 임재영 선생님에게 사랑과 감사의 마음을 전합니다.

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A Retrospective Study for Prediction of Factors Affecting Survival of Primary Molars Following Pulpotomy with Mineral Trioxide Aggregate

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(Directed by professor Hyung-Jun Choi, D.D.S.,M.S.,Ph.D.)

The aim of the present study was to evaluate potential factors influencing the success rates of mineral trioxide aggregate (MTA) pulpotomy performed in primary molars.

A total of 347 teeth treated between March 2012 and December 2016 in 258 patients, with a mean age of 5.3±1.7 years, were included in the analysis. Kaplan-Meier analyses were used to analyze were used time-to failure. Multivariate Cox regression analysis with shared frailty was used to evaluate the clinical factors associated with failures

The mean (standard deviation) follow-up period was 35.8 (19.6) months. Within 84 months, the survival rate was 87.1%. In multivariate Cox regression, treatment performed in lower primary molars had a lower survival rate than upper primary molars (hazard ratio [HR] = 3.38, P=0.012). Caries extension below the cemento-enamel junction had more risk of failure (HR = 10.9, P<0.001). Final restoration using resin modified glass ionomer or amalgam (direct filling) had a lower survival rate than stainless steel crown (HR = 5.62, P=0.002).

Clinical variables such as arch type, degree of caries extension, and type of final restoration may affect the survival of primary molars following MTA pulpotomy. The results of this study indicate that specific clinical variables can be used to predict the prognosis of MTA pulpotomy in primary teeth, and estimate the risk of treatment failure. Assessments of these variables should be performed in the context of evidence-based clinical decision making.

Key words: Pulpotomy, Primary teeth, Mineral Trioxide Aggregate, Survival analysis, Risk factors

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I. Introduction

A pulpotomy is indicated in primary teeth when the pulp tissue is exposed during excavation of a carious lesion or trauma (Fuks, 2002; Fuks, et al., 2019). It is a form of vital pulp therapy widely used in both permanent and primary teeth for maintaining pulp vitality and function. As a result of continuous advancements in biomedical research, new methods of pulp treatment aimed at regeneration of the dentin-pulp complex, such as indirect pulp capping, direct pulp capping, and pulpotomy, have been developed. These methods are based on the tissue repair mechanisms by the pulp-dentin complex regulating dentinogenic action (Tziafas, 2004).

Several medicaments may be used as a pulp dressing material in pulpotomized teeth, including Buckley's Solution of formocresol (FC), calcium hydroxide (CH), and mineral trioxide aggregate (MTA) (Smail-Faugeron, et al., 2018). FC has been a popular pulp dressing material for over 70 years. When applied on pulp remnants, adjacent pulp tissue is altered by the formaldehyde. Altered tissue appears 'fixed' immediately and liquifactive necrosis doesn't occur in the root canal (Moretti, et al., 2008; Peng, et al., 2006). However, formaldehyde, a major component of FC, has been reported to be distributed systemically after pulpotomy (Myers, et al., 1978), shows cytotoxicity, may act as a potential carcinogen, and cannot exclude the possibility of harmful side effects such as immune sensitization, mutagenesis and carcinogenesis (Srinivasan, et al., 2006b; Sun, et al., 1990). In some countries, FC is not used anymore as a pulp dressing material mainly because of safety issues, such as immune sensitization, mutagenesis, and carcinogenesis (Fuks, 2008; Srinivasan, et al., 2006a; Sun, et al., 1990). Furthermore, as the clinical success rate of CH pulpotomy shows huge variation, ranging 31–100%, and there is a risk of internal root resorption (Schröder, 1978; Waterhouse, 1995; Waterhouse, et al., 2000), CH is no longer used for pulpotomy in primary teeth.

Since its introduction as a material for pulpotomy in primary molars, MTA has attracted attention for the following advantages: an excellent biocompatibility, a high sealing capacity, an alkaline pH, and antimicrobial effects (Kang, et al., 2011; Mitchell, et al., 1999). MTA has also been shown to stimulate fibroblasts in primary teeth, leading to the release of cytokines, which promote hard tissue formation (Ferreira, et al., 2009). Previous studies have demonstrated the potential of MTA to stimulate tissue regeneration during vital pulp therapy (Agamy, et al., 2004; Cardoso-Silva, et al., 2011; Ng and Messer, 2008; Torabinejad and Chivian, 1999).

According to recent studies, the success rates of MTA pulpotomy range from 88.2–100% (Celik, et al., 2013; Holan, et al., 2005; Liu, et al., 2011; Musale and Soni, 2016; Yildiz and Tosun, 2014). A randomized controlled trial comparing three commercially available medicaments containing MTA (ProRoot MTA, OrthoMTA, and RetroMTA) for use in pulpotomized primary molars, reported equivocal success rates (Kang, et al., 2015). A systematic review of randomized controll ed trials comparing the use of MTA and FC following pulpotomy in primary molars, concluded that treatment outcomes were more favorable for the former medicament (Shirvani and Asgary, 2014).

Current evidence strongly suggests the use of MTA(Dhar, et al., 2017; Farsi, et al., 2005; Fuks, 2002; Holan, et al., 2005; Stringhini Junior, et al., 2015). Although a review performed by Anthonappa et al. concluded that several studies were biased (Anthonappa, et al., 2013), other systematic reviews and network meta-analysis concluded that the use of MTA could be the first choice for primary molar pulpotomy (Lin, et al., 2014). Despite the evidence for MTA as the medicament of choice for pulpotomy in primary teeth, no prior studies have used multivariate analysis to investigate potential factors that may influence the long-term prognosis of this treatment.

Therefore, the aim of this study was to evaluate prognostic factors for the long-term survival of primary molars after MTA pulpotomy using three different types of MTA (ProRoot MTA, OrthoMTA, and RetroMTA).

II. Materials and Methods

The study protocol was approved by the Institutional Review Board (approval no. IRB 2-2019-0043) at Yonsei University Dental Hospital, and was carried out in accordance with institutional guidelines.

1. Patient selection

All pulpotomy were done by pediatric dentistry residents and faculty staffs at the Department of Pediatric Dentistry at Yonsei University Dental Hospital, Seoul, Korea. Patients who underwent MTA pulpotomy on at least one of their primary molars, between March 2012 and December 2016, were identified in an electronic clinical database system. Only cases with at least six months clinical and/or radiographic follow-up after the completion of pulpotomy were included.

2. Treatment procedures

Pulpotomy was carried out according to the indications stated in the American Academy of Pediatric Dentistry guidelines for pulp therapy in primary teeth (Pulp Therapy for Primary and Immature Permanent Teeth, 2018): (i) teeth with pulp tissue exposed during excavation of a carious lesion or trauma; (ii) teeth without adverse clinical signs such as sensitivity, pain, or swelling; and (iii) teeth without radiographic signs of infection or pathologic resorption.

Periapical X-rays were taken preoperatively for diagnosis and/or exclusion of interradicular or periapical infections or pathologic resorption. Block or infiltration anesthesia (2% lidocaine containing 1:80,000 epinephrine; Huons, Seongnam, Korea) was administered prior to isolation of the tooth with a rubber dam. Initial caries removal was performed with a No. 330 sterile carbide bur (H7 314 008, Brasseler, Lemgo, Germany) in a high-speed handpiece, and completed with a sterile round carbide bur (No. 4, Prima Classic RA4, Prima Dental Group, Gloucester, UK)-in a low-speed handpiece. Upon pulpal exposure, the pulp chamber was opened with the sterile high-speed carbide bur. Amputation of the coronal pulp tissue using a sterile sharp discoid spoon excavator or a sterile low-speed round carbide bur until remnant tags are completely removed and the orifices of the stumps could be seen clearly. After removal of the coronal pulp tissue, hemostasis was achieved by applying cotton pellets wetted with sterile saline. If hemostasis was achieved within several minutes, ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK, USA), OrthoMTA (BioMTA, Seoul, Korea) or RetroMTA (BioMTA, Seoul, Korea) was applied in accordance with the manufacturer's instructions. After MTA application, glass ionomer (Ketac molar; 3M ESPE, St. Paul, MN, USA) base was applied over MTA. Most of the teeth were restored with stainless steel crowns (SSC, 3M ESPE, St. Paul, MN, USA). Patient who did not want SSC restoration, tooth was restored using amalgam (Ultracaps; SDI, Victoria, Australia), or resin-modified glass Ionomer (RMGI, GC Fuji II LC; GC Corp, Tokyo, Japan). The patients were called for follow-up visits at 1, 3, and 6 months after the treatment, and every 6 months thereafter. At each visit, a clinical examination of the treated tooth was performed, and a periapical radiograph was taken.

3. Data collection

The dental records of each patient were obtained from the electronic clinical database, and factors potentially affecting the treatment outcome were recorded. These included both sociodemographic and clinical variables: sex (boys or girls); age (under 6 years or over 6 years); arch type (upper or lower); type of tooth (first primary molar or second primary molar); previous restoration (yes or no); cavitation (yes or no); cavity form (class I or class II); caries extension (below cemento-enamel junction [CEJ] or above CEJ); type of MTA used (ProRoot MTA, OrthoMTA, or RetroMTA); final restoration (SSC or direct filling : RMGI or amalgam); and operator (faculty or resident).

4. Evaluation of treatment outcome

Treated teeth were evaluated on the basis of clinical records and periapical radiographs obtained during the follow-up visits. The treatment was considered to have failed when one or more of the following signs were observed: (i) spontaneous pain or tenderness to percussion/palpation; (ii) pathologic mobility; (iii) inflammation, abscess, or fistula formation in the adjacent soft tissues; (iv) periapical/furcal radiolucent lesion; and (v) internal/external root resorption not related to a normal exfoliation process. Calcific metamorphosis, such as pulp canal obliteration and dentin bridge formation, was not considered to indicate treatment failure. Teeth without a failure event by the time of the last follow-up assessment were considered to have undergone successful treatment.

The entry-point was defined as the date of MTA pulpotomy treatment by the dentist, and the end-point was defined as either the date of the last visit to the hospital or the date of observed tooth failure.

The evaluation of treatment outcome was performed by two experienced examiners. They were calibrated prior to the assessments by evaluating 30 periapical radiographs unrelated and independent from the present study. Following the calibration session, the preoperative, postoperative, and follow-up radiographs were evaluated by the same examiners in a random order and in a blinded manner. In case of disagreement, a consensus was reached following a discussion between the two examiners. The evaluation of the radiographs was repeated on a separate occasion 2 weeks later. Cohen's kappa statistic was 0.935 and 0.902 in the intra- and inter-examiner reliability tests, respectively.

5. Statistical analysis

Data analyses were performed with R version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria). The distribution of the treated teeth and their rates of success, according to the individual clinical variables, were tabulated in a descriptive analysis (Table 1).

The survival rates of the pulpotomized teeth were evaluated and described by Kaplan-Meier curves. The log rank test was used to calculate significant differences between the groups. The evaluation of the risk factors was performed using Cox proportional hazards models with shared frailty. These models consider that observations within the same group (the patient) are correlated, sharing the same frailty and being analogous to regression models with random effects. Univariate analysis (non-adjusted model) and multivariate analysis (adjusted model) were performed. Only those variables presenting with *P*-values less than 0.2 in the unadjusted assessment were selected for the multivariate analysis (Campagna, et al., 2018; Pedrotti, et al., 2017). Hazard ratios (HRs) and their 95% confidence intervals (95% CI) were obtained. The level of statistical significance was set at $P<0.05$.

III. Results

1. Clinical outcomes

A total of 347 teeth in 258 patients (107 girls and 151 boys), treated between March 2012 and December 2016, were included in the analysis. The mean (standard deviation, SD) age of the children was 5.3 (1.7) years old.

The distribution of success and failure of MTA pulpotomy according to the predictor variables and the results of the univariate Cox proportional hazard regression analyses are shown in Table 1. MTA pulpotomy was mostly carried out among boys (58.2%) and children less than 6 years old (59.1%). Treatment for primary first molars (68.3%) was more common than for primary second molars (31.7%), and treated teeth were more frequently located in the upper arch (52.4%) than in the lower arch (47.6%). Most teeth (81.0%) did not have a history of treatment. Most of the carious lesions prior to MTA pulpotomy were cavitated (70.9%) and extended above the CEJ (81.0%). Most of the pulpotomized teeth were dressed with RetroMTA (67.4%) and restored with SSC (87.6%).

The follow-up period varied from 6 to 84 months, with a mean (SD) of 35.8 (19.6) months. The distribution of success and failure during the follow-up period is shown in Fig. 1. During the follow-up period, 91.1% of the treated teeth (316 out of 347) were considered as successful. Radiographs of typical success and failure cases are shown in Fig. 2. The

Kaplan-Meier survival curve of the treated teeth is shown in Fig. 3a. The cumulative tooth survival rate was 87.1% after 84 months of evaluation.

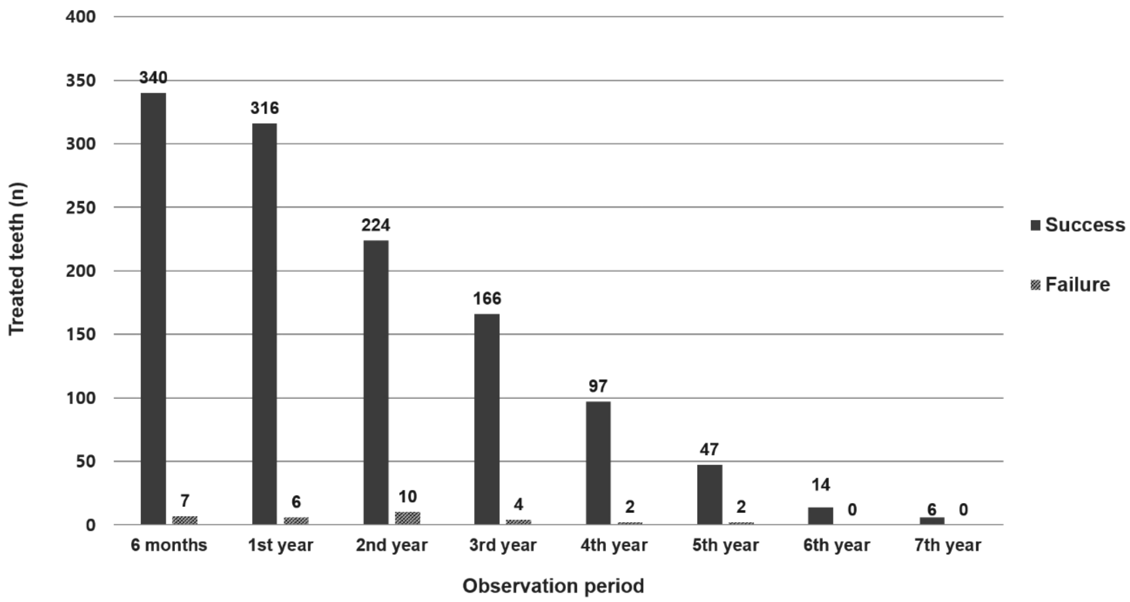

Figure 1. Success and failure distribution during the follow-up period

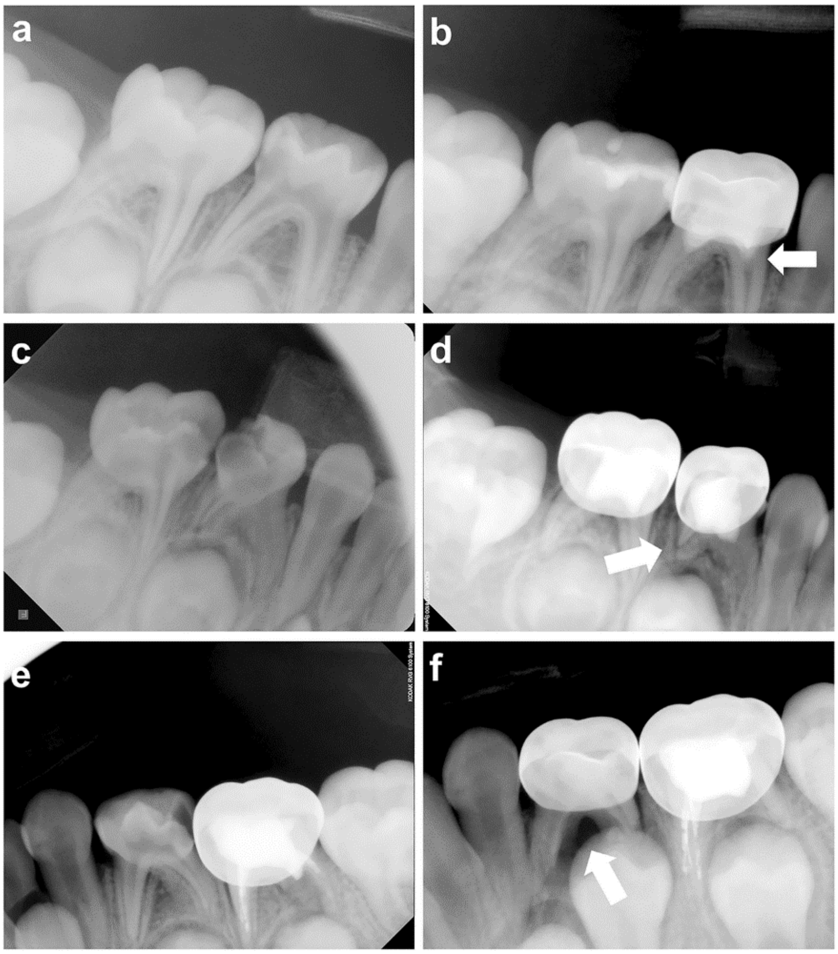

Figure 2. Periapical radiographs showing successful and failed MTA pulpotomy. (a) Pre-operative radiograph: 5Y 8M, M, #84, OrthoMTA, (b) 12-month follow-up radiograph: dentin bridge formation (white arrow) with no clinical symptom. (c) Pre-operative radiograph: 4Y6M, F, #84, RetroMTA, (d) 18-month follow-up radiograph: external root resorption with pathologic mobility (white arrow). € Pre-operative radiograph: 6Y5M, F, #74, RetroMTA, (f) 22-month follow-up radiograph: bone resorption involving furcation area with sinus tract formation (white arrow)

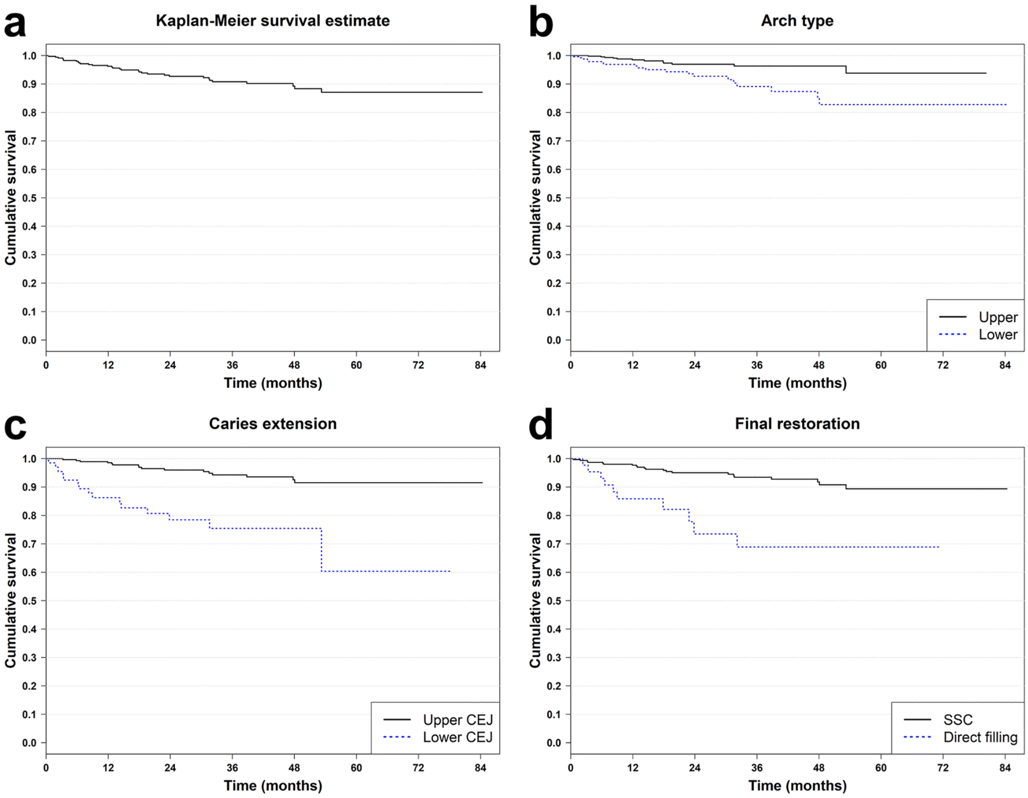

Figure 3. Kaplan-Meier survival curve of primary molars treated with MTA pulpotomy. (a) Overall cumulative survival rate. (b) Survival difference according to arch type (adjusted by caries extension and final restoration, log-rank test: $P = 0.01$). (c) Survival difference according to caries extension (log-rank test: $P < 0.001$). (d) Survival difference according to final restoration (log-rank test: $P < 0.001$)

2. Cox regression analysis

The crude HRs for each independent predictor variable, as determined via the univariate analysis, are shown in Table 1. “Arch type,” “type of tooth,” “previous restoration,” “caries extension,” “type of MTA,” and “final restoration” were associated with the failure rate.

The results of the multivariate analysis (adjusted HR) are shown in Table 2. Treatment performed in primary lower molars had a risk of failure that was 3.38 times higher than that of treatment performed in primary upper molars (P=0.012). Caries extension below the CEJ was associated with a 10.9 times higher risk of failure than caries located above the CEJ (P<0.001). Direct filling as a final restoration was associated with a 5.62 times higher risk of failure (P=0.002) compared to an SSC.

Table 1. Distribution of MTA pulpotomy success and failure according to the predictor variables and the results of the univariate Cox proportional hazard regression analysis (N=347 teeth)

Variables	Treatment N (%)	Success N (%)	Failure N (%)	p-value	HR
Gender					
Boys	202 (58.2)	185 (91.6)	17 (8.4)		1
Girls	145 (41.8)	131 (90.3)	14 (9.7)	0.603	1.21
Age (years)					
<6	205 (59.1)	188 (91.7)	17 (8.3)		1
≥6	142 (40.9)	128 (90.1)	14 (9.9)	0.317	1.45
Arch type					
Upper	182 (52.4)	170 (93.4)	12 (6.6)		1
Lower	165 (47.6)	146 (88.5)	19 (11.5)	0.164	1.67
Type of tooth					
1st primary molar	237 (68.3)	220 (92.8)	17 (7.2)		1
2ndprimary molar	110 (31.7)	96 (87.3)	14 (12.7)	0.102	1.81
Previous restoration					
Yes	66 (19.0)	58 (87.9)	8 (12.1)		1
No	281 (81.0)	258 (91.8)	23 (8.2)	0.144	0.55
Cavitation					
Yes	246 (70.9)	222 (90.2)	24 (9.8)		1
No	101 (29.1)	94 (93.1)	7 (6.9)	0.343	0.67
Cavity form					
Class I	65 (18.7)	60 (92.3)	5 (7.7)		1
Class II	282 (81.3)	256 (90.8)	26 (9.2)	0.543	1.34
Caries extension					
Above CEJ	281 (81.0)	265 (94.3)	16 (5.7)		1
Below CEJ	66 (19.0)	51 (77.3)	15 (22.7)	<0.001	5.86
Type of MTA					
ProRoot MTA	43 (12.4)	42 (97.7)	1 (2.3)		1
OrthoMTA	70 (20.2)	64 (91.4)	6 (8.6)	0.244	3.52
RetroMTA	234 (67.4)	210 (89.7)	24 (10.3)	0.165	4.13
Final restoration					
SSC	304 (87.6)	283 (93.1)	21 (6.9)		1
Direct	43 (12.4)	33 (76.7)	10 (23.3)	<0.001	4.93
Operator					
Resident	147 (42.4)	131 (89.1)	16 (10.9)		1
Faculty	200 (57.6)	185 (92.5)	15 (7.5)	0.260	0.67

Table 2. Multivariate Cox proportional hazard regression analysis (adjusted HR; 95% confidence interval [CI]) for MTA pulpotomy failure

Variables	*P*-value	HR (adjusted)	95% CI
Arch type			
Upper		1	Reference
Lower	0.012	3.38	1.30-8.76
Type of tooth			
1^{st} primary molar		1	Reference
2^{nd} primary molar	0.192	1.85	0.73-4.67
Previous restoration			
Yes		1	Reference
No	0.582	0.74	0.25-2.17
Caries extension			
Above CEJ		1	Reference
Below CEJ	<0.001	10.9	4.05-29.4
Type of MTA			
ProRoot MTA		1	Reference
OrthoMTA	0.322	3.39	0.30-37.8
RetroMTA	0.346	2.96	0.31-28.1
Final restoration			
SSC		1	Reference
Direct filling	0.002	5.62	1.89-16.7

3. Kaplan-Meier survival graphs difference between group

The survival differences according to the significant prognostic factors (arch type, caries extension, final restoration) are shown in the Kaplan-Meier survival curve. The survival difference by arch type, adjusted by the other significant factors (caries extension, final restoration), is shown in Fig. 3b. The survival difference according to caries extension is presented in Fig. 3c. The survival difference according to the type of final restoration is shown in Fig. 3d.

IV. Discussion

This study was designed to identify clinical factors that affect the survival of primary molars after MTA pulpotomy. This study investigated the long-term outcomes of primary teeth following MTA pulpotomy, based on both clinical and radiographic assessments. A total of 347 treated teeth in 258 patients were included in this study. The survival rate of pulpotomized teeth after 84 months of follow-up was 87.1%. These results are in accordance with those of previous studies, which have reported success rates ranging from 88.2–100% (Celik, et al., 2013; Holan, et al., 2005; Liu, et al., 2011; Musale and Soni, 2016; Yildiz and Tosun, 2014). The slightly lower success rate in the present study may have been due to the longer follow-up period.

We evaluated several potential prognostic factors. Arch type, extension of caries, and final restoration had significant effects on failure rates. No significant differences in the failure rates were found between the different pulp dressing materials. This supported the results of a previous randomized controlled trial (Kang, et al., 2015), which reported equivocal success rates for RetroMTA, OrthoMTA, and ProRoot MTA over a 12-month period. It is noteworthy that our retrospective study demonstrated a similar result over a longer follow-up period.

In this study, the success rates of MTA pulpotomy varied according to arch type. Primary mandibular molars showed a lower success rate than primary maxillary molars. Previous study has also reported similar results. Strange et al. reported that primary mandibular molars had a significantly lower success rate than primary maxillary molars; however, they reasoned that this result was due to the greater difficulty associated with the evaluation of treatment outcomes in primary maxillary molars, since maxillary sinuses obscured the radiographic changes (Strange, et al., 2001). This explanation may be relevant in the present study. Moreover, as it is more difficult to obtain complete rubber dam isolation of mandibular teeth, the possibility of coronal leakage during pulpotomy of mandibular primary molars is high. Taken together, the results of this paper do not mean that pulpotomy should only be attempted in maxillary primary molars, but that obtaining adequate rubber dam isolation is important during pulpotomy in mandibular primary molars.

The failure rate was observed to be higher when caries extended below the CEJ. Coronal leakage can be a major determinant of endodontic treatment failure (Awawdeh, et al., 2018; Ward, 2002). Notably, a previous study has shown that the thickness of MTA affects its sealing ability, and should be greater than 3 mm (Olmez, et al., 2008). Due to the divergent profile of primary molars (Gross and Nowak, 2019), it is often difficult to apply an adequate thickness of MTA, especially in cases where caries extends to the cervical region.

When pulpotomized teeth were restored RMGI or amalgam rather than SSC, higher failure rate (HR=6.67) was observed. SSCs are traditionally recommended as the final restoration following pulp therapy to ensure a biological seal, which is critical for long-term success (Seale and Randall, 2015). This guideline is based on previous studies, which have demonstrated better treatment outcomes with SSCs than with other types of restorations following pulp therapy in primary teeth (Al-Zayer, et al., 2003; Guelmann, et al., 2005; Hutcheson, et al., 2012).

It is important to obtain a biological seal to increase the success rate of MTA pulpotomy. The clinical recommendations to prevent coronal leakage are as follows. If caries extends beyond the CEJ, it is better to avoid pulpotomy if obtaining an MTA thickness of 3 mm is not possible. After performing pulpotomy, it is necessary to restore the tooth with SSC as soon as possible. Obtaining adequate rubber dam isolation is important during pulpotomy in mandibular primary molars. Moreover, if a clinician cannot restore the tooth with SSC immediately, efforts should be made during the base filling process to obtain a proper seal.

A limitation of this study was its retrospective design. As such, there was a lack of standardization of the treatment protocol, including the indication and selection of the different treatment options. Additional studies utilizing a prospective design, with longer evaluation periods, as well as standardized treatment protocols, are required.

This study was the first to identify predictors of long-term survival following pulpotomy utilizing various types of MTA in primary teeth. A high success rate (87.1%) was observed, and there were no statistically significant differences in tooth survival rate, between the dentists performing the pulpotomy. Given the proper indications, MTA pulpotomy should be considered the treatment of choice, due to its high success rate and low technique sensitivity.

V. Conclusion

The results of this study show high success rates of MTA pulpotomy (87.1%) 84 months after treatment. Arch type, extension of caries, and type of final restoration can significantly influence the success rates. Achieving a biological seal is important for a favorable treatment outcome.

To evaluate the treatment outcome of MTA pulpotomy more accurately, a prospective clinical study with standardized protocol is highly desirable.

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국문요약

Mineral Trioxide Aggregate를 사용한 유구치 치수절단술의 생존에 영향을 미치는 인자 예측을 위한 후향적 연구

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지도교수: 최형준

유구치의 경우 치수강이 넓고 치질의 두께가 얇아 치수가 와동 형성중이나 외상에 의해 노출되는 경우가 잦다. 이 경우 치수절단술의 적응증이 되며, mineral trioxide aggregate (MTA)가 유구치 치수절단술을 위한 재료로 개발되어 사용되고 있다. 이 연구의 목적은 유구치의 MTA 치수절단술의 성공률에 영향을 미치는 잠재적 인 요인을 평가하는 것이다.

이 연구에는 2012 년 3 월부터 2016 년 12 월 사이에 연세대학교 치과대학병원 소아치과에서 치수절단술 치료를 받은 258 명의 환자, 총 347 개의 치아가 포함되었다. 분석에 포함된 환자의 평균 연령은 5.3 ± 1.7 세였다. 치료 실패의 발생 시점을 분석하기 위해 Kaplan-Meier 생존분석을 사용하였고, 실패와 연관된 임상적 요인을 평가

하기 위해 Cox 비례위험모형을 이용한 회귀 분석을 시행하였다.

평균 추적 기간은 35.8 ± 19.6 개월이었다. 84 개월 추적 관찰 후 생존율은 87.1 %였다. 다변량 Cox 회귀 분석 결과, MTA 치수절단술 후 하악 유구치의 생존률은 상악 유구치보다 낮았다 (Hazard ratio [HR] = 3.38, P = 0.012). Cemento-enamel junction 하방으로 우식이 연장된 경우 실패율이 더 높았다 (HR = 10.9, P <0.001). 최종 수복시 직접 충전법(레진 강화형 글래스아이오노머 또는 아말감)을 사용한 경우 기성금속관을 사용한 경우보다 생존율이 낮았다 (HR = 5.62, P = 0.002).

악궁의 종류, 우식의 연장 정도 및 최종 수복물의 유형과 같은 임상적 변수는 MTA 치수절단술후 유구치의 생존에 영향을 미칠 수 있다. 본 연구의 결과는 특정 임상 변수를 유구치 MTA pulpotomy의 예후를 예측하고 치료 실패의 위험을 추정하는 데 사용될 수 있음을 보여준다. 이 연구에서 MTA 치수절단술의 예후를 예측할 수 있는 임상적 변수를 발견하여 치료계획 수립 시 근거 중심 의학에 기반한 의사 결정과정에 사용될 수 있을 것으로 기대한다.

핵심되는 말: 치수절단술, 유구치, Mineral Trioxide Aggregate, 생존분석