Efficacy of Aloe Vera as A Pulpotomy Agent in Children Primary Teeth: Clinical and Radiographic Studies

Sara Gonna1, PhD; Nagwa Ghoname2, PhD; Amal Kabbash3, PhD; Akira Yagi4, PhD

1 Lecturer of Pediatric Dentistry, Tanta University, Japan; 2 Professor of Pediatric Dentistry, Tanta University, Japan; 3 Professor of Pharmacognosy Department, Faculty of Pharmacy, Tanta University, Japan; 4 Editor in-Chief of Journal of Gastroenterology and Hepatology Research; Emeritus Professor, Fukuyama University, Hiroshima, Japan.

Conflict-of-interest statement: The authors declare that there is no conflict of interest regarding the publication of this paper.

Open-Access: This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

Correspondence to: Akira Yagi, PhD, Professor Emeritus, Fukuyama University, Hiroshima, Japan.
Email: 0131akirayagi@gmail.com
Telephone: +81-92-938-2717

Received: May 31, 2019
Revised: July 12, 2019
Accepted: July 15, 2019
Published online: October 21, 2019

INTRODUCTION

Maintenance of the primary dentition in a non-pathologic and healthy condition is important for the well-being of the child as well as for proper mastication, esthetics, phonetics, space maintenance and prevention of aberrant habits[1].

Pulpotomy is one of the most widely accepted clinical procedures for treating cariously exposed pulp in primary teeth. The rationale of this technique is based on the healing ability of the radicular pulp tissue following surgical amputation of the affected or infected coronal pulp[2].

Pulpotomy can be performed using different techniques including;
MATERIALS AND METHODS

This study was conducted as a clinical trial, it was carried out at Pediatric Dentistry Department, Faculty of Dentistry, Tanta University. This study was carried out on thirty healthy children aged from four to eight years, they were selected from patients attending outpatient clinic of Pediatric department. Each child had at least bilateral deep carious lower primary molars (D&E) indicated for pulpotomy Figure 1.

Approval for this research was obtained from Faculty of Dentistry, Tanta University Research Ethics Committee. The purpose of the present study was explained to the patients and informed consents were obtained according to the guidelines on human research adopted by the Research Ethics Committee Faculty of Dentistry, Tanta University.

Inclusion criteria
A-Clinical criteria\textsuperscript{10}: (1) No evidence of clinical signs and symptoms of pulp degeneration such as; spontaneous throbbing pain, pain on percussion, tooth mobility, soft tissue swelling, fistula or sinus tract. (2) Absence of pulp hyperemia that require additional procedure. (3) Healthy children free from any medical condition such as heart or leukemia that contraindicate pulp therapy. (4) Restorable teeth. (5) Patient and parent cooperation.

B-Radiographic criteria\textsuperscript{10}: (1) No pathological external or internal root resorption. (2) Absence of calcific pulp degeneration. (3) Absence of furcation radiolucency.

Preparation of acemannan sponge

\textit{Aloe vera} polysaccharide fraction: Fresh \textit{Aloe vera} gel (100g) was homogenized and centrifuges at 9 x 10^3 g for 10 min. The supernatant was dialyzed with molecular weight 8000 cut-off membrane against distilled water for 36 hours and the non-dialysate (1g) was obtained as polysaccharides fraction after lyophilization, 0.4% acemannan solutions (w/v) were frozen at -80°C degree for 16 h and lyophilized overnight. Then the sponges are sterilized by gamma irradiation and tested for endotoxin contamination. The endotoxin level of the acemannan sponges are assessed using the Traditional Kinetic Limulus Amebocyte Lysate (LAL) assay kit (Lonza, Inc., Allendale, NJ, USA) following the manufacturer’s instructions. The endotoxin level is measured using ELISA after mixing the sample with LAL reagent and comparing it to a standard curve. Endotoxin levels are 4.30 EU/mg sponge\textsuperscript{36}. Acemannan sponge, provided by Prof. Yagi A., Emeritus, Fukuyama University, Hiroshima, Japan (Figure 2).

Technique

Pre-operative periapical radiographs were obtained to assess the tooth condition and to ensure proper case selection. Size (0 or 1) radiographic films were used to accommodate the pediatric mouth using Extension Cone Parallel technique (XCP). The sixty selected primary molars out of thirty children were randomly divided into two groups of thirty teeth for each, according to the material used, Group I (Study group): Treated with acemannan and Group II (control group): Treated with formocresol.

Pulpotomy procedure

The procedure started with profound local anesthesia and rubber dam isolation, then caries was removed and conventional pulpotomy technique was performed. The roof of the pulp chamber was removed using a sterile high-speed bur No.330 with water spray, and the coronal tissue was then amputated by sharp sterile spoon excavator followed by irrigation with normal saline. Initial pulpal homeostasis was obtained using moistened cotton pellet gently pressed against the amputated pulp stump. In group I acemannan sponge was mixed with distilled water to form a viscous solution, then a cotton pellet...
Acemannan as a pulpotomy agent in primary teeth

Figure 3 Clinical procedure using acemannan sponge. (A) Photograph shows the preoperative bilateral carious mandibular first molar. (B) Access opening of mandibular right second molar after removal of pulp tissue. (C) Applying moistened cotton with acemannan in the pulp chamber. (D) Stainless-steel crown in place at the same visit. (E) Application of reinforced zinc oxide eugenol.

Figure 4 Clinical procedure using FC. (A) Preoperative photograph shows carious mandibular left second molar. (B) Access opening of mandibular second molar after removal of pulp tissue. (C) Application of cotton pellet moistened with Buckly’s formocresol. (D) Application of reinforced zinc oxide eugenol. (E) Stainless-steel crowns in place at the same visit. (F) Stainless-steel crowns in both side.

moistened with it was applied on the pulp stump for 3 minutes, then the cotton will be removed, the cavity was sealed with reinforced zinc oxide eugenol. At the same visit, the tooth was restored with stainless-steel crown cemented with glass inomer cement as a final restoration (Figure 3). In Group II, a small sterile cotton pellet moistened with Buckly’s formocresol was placed over the pulp stumps for 5 minutes, then the pellet was removed and the cavity was sealed with reinforced zinc oxide eugenol. At the same visit, the tooth was restored with stainless-steel crown cemented with glass inomer cement as a final restoration (Figure 4).

RESULTS

At the end of the study at twelve-month follow-up one patient was lost leaving 29 patients for evaluation, the overall clinical success rate of acemannan group was 96.5%, while FC group was 89.6%. The two groups were clinically successful with no statistically significant difference between them. ($p = 0.148$) (Table 1).

In acemannan group, during the follow up periods all cases showed no sign of pain, gingival swelling or mobility, except at twelve month one case came with pain and gingival swelling. While, for formocresol group, one case represented with pain and gingival swelling at 3 month and another two cases at twelve month. There was no statistically significant difference between the two groups at different follow up periods as shown in Table 2. All the failed cases were managed by pulpectomy or extraction and space maintainer.

The overall radiographic success rate of acemannan group was 93.1%, while for formocresol group was 86.2%. There was no statistically significant difference between the two groups ($p = 0.385$) (Table 3 and Figures 5 and 6).

Throughout the follow-up periods, treated teeth in acemannan
group revealed no evidence of radiographic changes at three and six month follow-up. While, one tooth (3.3%) after nine months and another one (3.4%) after twelve months showed furcation radiolucency. In formocresol group, treated teeth showed no evidence of radiographic changes at three and six month follow-up. While, one tooth (3.3%) showed furcation radiolucency and another one (3.3%) showed abnormal root resorption and periodontal ligament space defect at nine month. At twelve month, one tooth (3.4%) showed also furcation radiolucency, and another one (3.4%) showed abnormal root resorption and widening of periodontal ligament space. There was no statically significant difference between the two groups at different follow up period as shown in Table 4.

**DISCUSSION**

An ideal pulpotomy material or drug must preserve healthy radicular pulp tissue, be highly biocompatible, prevent bacterial micro leakage, has the ability to promote healing, prevent bacterial microleakage and should not interfere with the physiological root resorption process.

Advances in biomedical research open avenues for design of new materials for pulpotomy treatment, aiming at regeneration of dentin–pulp complex. So, this study was conducted to assess the efficacy of acemannan as a pulpotomy agent compared to formocresol in primary teeth.

The age group selected for this study was from four to eight years to preserve the primary molars till the time of exfoliation, as premature loss of primary molars is one of the factors that are responsible for space loss and malocclusion. Also, the selected cases had bilateral deep carious primary molars, to perform the treatment of both groups under the same environmental factors for accurate comparable results.

In the current study, formocresol was used for comparison because it is still considered the gold standard when compared with all pulpotomy agents and medicaments due to its bacteriostatic, fixative properties and high clinical success rates.

It seems very important to identify novel and effective pulpotomy agents to increase the rate of success of pulpotomy procedures. Therefore, several investigations have been used to evaluate the clinical and radiographical success of the variable pulpotomy agents in primary teeth, such as the presence of pain or swelling as well as the indication of periapical or bifurcation change seen in radiograph.[11,12]

So, in this study, clinical as well as radiographic and

---

**Table 1** Overall clinical success rates of the tested materials after twelve months follow up.

| Groups | Success N [%] | Failure N [%] | \( \chi^2 \) | \( P \) |
|--------|--------------|--------------|-----------|-------|
| AC     | 28 (96.5)    | 1 (3.4)      | 3.819     | 0.148 |
| FC     | 26 (89.6)    | 3 (10.3)     | \( 0.754 \) | 0.385 |

N: Total number of cases; \( \chi^2 \): Chi square test; FE: Fisher Exact for chi square test; AC: Acemannan; FC: Formocresol.

**Table 2** Comparison of failure cases in the tested groups at different follow up period.

| Failure criteria | 3 months | 6 months | 9 months | 12 months | \( \chi^2 \) | \( P \) |
|-----------------|----------|----------|----------|-----------|-----------|-------|
| Pain            | 0.75     | 1.403    | 0.357    |           | 0.236     | 0.55  |
| Gingival Swelling | 1s       | 1.403    | 0        | 0.357     | 0.236     | 0.55  |
| Mobility        |          |          |          |           |           |       |
| Total           | 0        | 1        | 0        | 0         | 1         | 2     |

AC: Acemannan; FC: Formocresol; Same patient presented with different symptoms; \( \chi^2 \): Chi square test; FE: Fisher Exact for chi square test.

**Table 3** Overall radiographic success and failure in the study groups.

| Groups | Success [N [%]] | Failure [N [%]] | \( \chi^2 \) | \( P \) |
|--------|-----------------|-----------------|-----------|-------|
| AC     | 27(93.1)        | 2(6.9)          | 0.754     | 0.385 |
| FC     | 25 (86.2)       | 4 (13.7)        |           |       |

N: Total number of cases; \( \chi^2 \): Chi square test; FE: Fisher Exact for chi square test.

**Table 4** Comparison of radiographic failure rates for the tested groups at different follow up period.

| Failure criteria | 3 months | 6 months | 9 months | 12 months | \( \chi^2 \) | \( P \) |
|-----------------|----------|----------|----------|-----------|-----------|-------|
| Furcation radioluency |         |          |          |           |           |       |
| Periapical radioluency |         |          |          |           |           |       |
| Abnormal root resorption |         |          |          |           |           |       |
| Periodontal ligament defects |         |          |          |           |           |       |
| Total            | 0        | 0        | 0.357    | 0.357     |           |       |

\( P \): p value; \( \chi^2 \): Chi square test; FE: Fisher Exact for chi square test; n: same patient with different
histopathological examination were used during follow up, since the clinical and radiographic study of applied novel material are not sufficient. For overall evaluation, histopathological examination has long been suggested as the best method to evaluate the effectiveness of a biomaterial at the cellular and pulp tissue levels which may be difficult to feasible in the human especially in pediatric age group[6,14].

In the present study, the overall clinical success rate of acemannan after one year was 96.5%. Most of the cases were clinically free from pain sensation, mobility and gingival abscess formation. These results may be contributed to anti-inflammatory, anti-bacterial, immunoregulatory function, healing and regenerative properties of Aloe vera[5,6].

This result coincides with Songsiripraduboon et al[8], they reported 100% success rate of acemannan as a direct pulp capping material. In addition Khairwa et al[8], found that a mixture of zinc oxide powder and Aloe vera gel in primary teeth has showed 93% clinical success rate when used as a root canal filling material in primary teeth.

In the present study, radiographic success rate of acemannan was 93.1%, this results in accordance with Songsiripraduboon et al[8], they reported 85% radiographic success rates when acemannan was used as a direct pulp capping material in human primary teeth. While, Khairwa et al[8], reported 73% radiographic success rates when Aloe vera was mixed with zinc oxide powder as a root canal filling material in primary teeth.

Regarding FC evaluation in the present study, the clinical success rate was 89.6%. These findings agreed with the previous studies who reported (93.3%) by Eidelman et al[9], 98.6% by Farsi et al[9] and 100% by Noorollahian[10]. While radiographic finding in FC group was 86.2%. These findings agreed with the results obtained by Farsi et al[9], (86.8%); Huth et al[11] (85%), and Mesut et al[12] (90.4%).

The explanation for the difference in the overall clinical and radiographic success rates of both group in this study may be attributed to the fact that the clinical and radiographic success not always correspond. Fuks et al[9] reported that chronic inflammation of the pulp may be present without periapical or interradicular abscess formation and the tooth may be clinically and radiographically normal.

Furcation radiolucency and abnormal root resorption were observed as common radiographic findings in formocresol group in the current study. These findings were in accordance with another different studies (Ibricicovic and Al-Jame,[11] Holan et al[12], Ruby et al[12], Havale et al[12]; Vildirim et al[12]) contributing the radiographic changes after FC pulpotomy to different factors, such as the possibility of penetration of formaldehyde through the pulpal floor with subsequent damage to the interradicular area. In the acemannan group, only one case presented with gingival swelling, this may be related to traumatic cutting during pulpotomy procedure or the presence of an extrapulpal blood clot that would cause chronic inflammation.

CONCLUSIONS

Within the context of observed results, it is possible to conclude that acemannan sponge (AHM) showed high clinical and radiographic success rate compared to formocresol as a pulpotomy agent in molars. It can be considered as an acceptable biomaterial for vital pulp therapy of deep caries in primary teeth.

ACKNOWLEDGMENTS

The authors express deep thanks to Mr.Yagi, S., CEO, Ellie Corporation, Shizuoka, Japan for providing aloe vera high molecular weight fractions.

REFERENCES

1. Mortada A and King NM. A simplified technique for the restoration of severely mutilated primary anterior teeth. J Clin Pediatr Dent, 2004; 28(3): 187-192. [PMID: 15163144]
2. Fubs AB, Guelmann M, Kapietzky A. Pulp therapy for the primary dentition. In: al C, editor. Pediatric dentistry infancy through adolescence. St Louis, Missouri: Elsevier Saunders, 2013; 3(1): 333-51.
3. Parisay I, GhodduSI J, and Forghani M. A review on vital pulp therapy in primary teeth. Iranian endodontic journal, 2015; 10(1): 6-15. [PMID: 25598803]; [PMCID: PMC4293574].
4. Zurn D and Seale SN. Light-cured calcium hydroxide vs formocresol in human primary molar pulpotomies: a randomized controlled trial. Pediatric dentistry, 2008; 30(1): 34-41. [PMID: 18402907].
5. Casas MJ, Layug M, Kennedy D, Johnston DH and Judd P. Outcomes of primary molar ferric sulfate pulpotomy and root canal therapy. Pediatr Dent. 2004; 26(1): 44-48. [PMID: 15080357].
6. Hunter M and Hunter B. Vital pulpotomy in the primary dentition: attitudes and practices of Specialists in Paediatric Dentistry practising in the United Kingdom. International Journal of Paediatric Dentistry, 2003; 13(4): 246-50. [PMID: 12834384].
7. Purohit RN, Bhatt M, Purohit K, Acharya J, Kumar R and Garg R. Clinical and Radiological Evaluation of Turmeric Powder as a Pulpotomy Medicament in Primary Teeth: An in vivo Study. Int J Clin Pediatr Dent, 2017; 10(1): 37-40. [PMID: 28377653]; [PMCID: PMC5360801]; [DOI: 10.5005/jp-journals-10005-1404].
8. Khairwa A, Bhat M, Sharma R, Satish V, Maganur P and Goyal A K. Clinical and radiographic evaluation of zinc oxide with aloe vera as an obturating material in pulpctomy: an in vivo study. J Indian Soc Pedod Prev Dent, 2014; 32(1): 33-8. [PMID: 24531599]; [DOI: 10.4103/0970-4388.127051].
9. Jittapiromsak N, Sahawat D, Banlunara W, Sangvanich P and Thunyatpisal P. Acemannan, an extracted product from Aloe vera, stimulates dental pulp cell proliferation, differentiation, mineralization, and dentin formation. Tissue Eng Part A, 2010; 16(6): 1997-2006. [PMID: 20088703]; [DOI: 10.1089/ten. TEA.2009.0593].
10. Mohammad SG, Raheel SA, and Baroudi K. Histological Evaluation of Allium sativum Oil as a New Medicament for Pulp Treatment of Permanent Teeth. The journal of contemporary dental practice, 2015; 16(2): 85-90. [PMID: 25906796].
11. Fuks AB and Eidelman E. Pulp therapy in the primary dentition. Curr Opin Dent, 1991; 1(5): 556-63. [PMID: 1807455].
12. Markovic, D, Zivojinovic V and Vucetic M. Evaluation of three root canal therapy. Eur J Paediatr Dent, 2005; 6(3): 133-8. [PMID: 16216093].
13. Kfir A and Basrani B. General Principles of radiology in endodontics. Endodontic radiology. 2nd ed. West Sussex: Wiley-Blackwell, 2012; 6(3): 5-17.
14. Woehrlen AE. Evaluation of techniques and materials used in pulpal therapy based on a review of the literature: part I. J Am Dent Assoc, 1977; 95: 1154-8. [DOI: https://doi.org/10.14219/jada.archive.1977.0194].
15. Reynolds T and Dweck AC. Aloe vera leaf gel: a review update. J Ethnopharmacol, 1999; 68(1-3): 3-37. [PMID: 10624859].
16. Hamman J. Composition and applications of Aloe vera leaf gel. Molecules, 2008; 13(8): 1599-616. [PMID: 18794775]; [PMCID: PMC6245421].
17. Songsiripraduboon SB, Sangvanich W, Trairatvorakul P, Thunyatpisal C. Clinical, radiographic, and histologic analysis of the effects of acemannan used in direct pulp capping of human teeth.
primary teeth: short-term outcomes. *Odontology*, 2016; **104**(3): 329-37. [PMID: 26264630]; [DOI: 10.1007/s10266-015-0215-4]

18. Eidelman E, Holan G, Fuks AB. Mineral trioxide aggregate vs. formocresol in pulpotomized primary molars: a preliminary report. *Pediatr Dent*, 2001; **23**(1): 15-8. [PMID: 11242724]

19. Farsi N, Alamoudi NB, Khalid MA. Success of mineral trioxide aggregate in pulpotomized primary molars. *Journal of Clinical Pediatric Dentistry*, 2005; **29**(4): 307-311. [PMID: 16161395]

20. Noorollahian H. Comparison of mineral trioxide aggregate and formocresol as pulp medicaments for pulpotomies in primary molars. *British dental journal*, 2008; **204**(11): 20-28. [PMID: 18425074]; [DOI: 10.1038/sj.bdj.2008.319]

21. Huth KC, Paschos E, Hajek AN, Hollweck R, Crispin A, Hickel R, Folwaczny M. Effectiveness of 4 pulpotomy techniques--randomized controlled trial. *Dent Res*, 2005; **84**(12): 1144-8. [PMID: 16304444]; [DOI: 10.1177/154405910504801210]

22. Mesut EO, Haluk B and Emre B. Clinical, Radiographic, and Histopathologic Evaluation of Nd: YAG Laser Pulpotomy on Human Primary Teeth. *J Endod*, 2007; **33**: 415-21. [PMID: 17368330]; [DOI: 10.1016/j.joen.2006.12.013]

23. Ilbricevic H, Al-Jame Q. Ferric sulphate as pulpotomy agent in primary teeth: twenty month clinical follow up. *J Clin Pediatr Dent*, 2000; **24**: 269-272. [PMID: 11314410].

24. Holan G, Eidelman E and Fuks AB. Long-term evaluation of pulpotomy in primary molars using mineral trioxide aggregate or formocresol. *Pediatric dentistry*, 2005; **27**(2): 129-36. [PMID: 15926290].

25. Ruby JD, Cox CF, Mitchell SC, Makhija S and Jackson J. A randomized study of sodium hypochlorite versus formocresol pulpotomy in primary molar teeth. *International Journal of Paediatric Dentistry*, 2013; **23**(2): 145-52. [PMID: 22502601]; [DOI: 10.1111/j.1365-263X.2012.01237.x]

26. Havale R, Aneugundi RT, Indushekar K and Sudha P. Clinical and radiographic evaluation of pulpotomies in primary molars with formocresol, glutaraldehyde and ferric sulphate. *Oral Health Dental Management*, 2013; **21**(1): 24-31. [PMID: 23474578].

27. Yildirim A, Ceren B, Feridun A, Ozlem M and Günseli G. Clinical and radiographic evaluation of the effectiveness of formocresol, mineral trioxide aggregate, Portland cement, and enamel matrix derivative in primary teeth pulpotomies: a two year follow-up. *Journal of Clinical Pediatric Dentistry*, 2016; **40**(1): 14-20. [PMID: 26696101]; [DOI: 10.17796/1053-4628-40.1.14]