Successful Application of Atelocollagen for Treatment of Perforated Teeth

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Objective: *Cervical or furcal root perforation is a serious clinical problem and one of its treatment modalities is perforation repair with composite resin. However, many cases still progress in inevitable extraction. When primary teeth are affected, early tooth loss can cause problems related to the eruption space for the permanent successors. The aim of the present study was to evaluate a novel clinical treatment method for perforated teeth.* ***Study design:*** *Atelocollagen was applied to perforated furcal and cervical areas of 13 primary teeth in 13 children aged 4-9 years and 8 permanent teeth in 8 adults aged 35-69 years after debridement with an electric knife. Thereafter, the final restorations were performed after confirming good tooth conditions. Clinical evaluations were performed at follow-up examinations at approximately 3-month intervals.* ***Results:*** *None of the treated primary teeth showed any clinical problems throughout the observation period, with eruption of the permanent successors noted in 7 cases. In the permanent teeth, no clinical problems were identified in any of the cases during follow-up periods of 10-60 months.* ***Conclusion:*** *This novel method may enable preservation of perforated primary teeth for a longer duration.*
Keywords: *perforated teeth, furcation, primary teeth, permanent teeth, atelocollagen,*
J Clin Pediatr Dent 36(1): 1–4, 2011

INTRODUCTION

Cervical or furcal root perforation of primary and permanent teeth is occasionally encountered in dental practices. It has in most cases an iatrogenic origin. A recent analysis of extraction of non-third-molar permanent teeth in Israel revealed that iatrogenic perforation occurred in approximately 10% of cases.[1] To conserve affected teeth, restoration of the perforated area with composite resin or mineral trioxide aggregate (MTA) has been used as a repair material for furcation perforations.[2-4] However, most affected teeth generally have a poor prognosis, with the formation of repeated abscess, and extraction is often considered to be inevitable.

Pediatric dentists, when they encounter furcation or cervical problems, tend to extract the involved tooth. Extraction itself does not cause significant problems when the permanent successor is ready to erupt. However, early loss of primary teeth can cause a variety of other major problems, such as reductions in the arch length and inclination of adjacent teeth.[5] To prevent such complications, use of a space maintainer is recommended. Recently, MTA was reported to be useful in a case of furcal perforation of the primary second molar in a child.[6]

The collagen molecule is a rod-type polymer with three polypeptide chains that form a helix, and the regions located at both ends, termed telopeptides, are known to have antigenic components.[7,8] Atelocollagen, which is extracted from collagen molecules after being treated with pepsin, is considered to be a proper biomaterial, since the main antigenic telopeptide regions are excluded. Atelocollagen has been used as a biocompatible material for skin reconstruction and have also been applied to oral membranes.[9-11] In addition, atelocollagen sponges have been placed into extraction sockets as a hemostatic agent.

In the present study, we successfully applied atelocollagen in perforated primary and permanent teeth. Based on the

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present results, we propose a novel method for application of this material to achieve a better prognosis.

MATERIALS AND METHODS

The protocol of the present study was approved by the Ethics Committee of Osaka University Graduate School of Dentistry. The adult subjects and parents of children were informed of the contents of the study, and provided a signed consent.13 primary teeth in 13 children aged 4-9 years (eight males, five females; cases C1-C13) (Table 1) and 8 permanent teeth in 8 adults aged 35-69 years (four males, four females; cases A1-A8) (Table 2) were included. The primary teeth consisted of four maxillary primary first molars, three maxillary primary second molars, four mandibular first primary molars, and two mandibular second primary molars, while the permanent teeth consisted of one maxillary first premolar, two second premolars, one first molar, one mandibular central incisor, one second premolar, one first molar, and one second molar. The cases were seen from 2006 to 2010 at a single private dental clinic in Moriguchi City. According to the individual circumstances, the affected teeth were first treated in different clinics prior to the patients attending this clinic. Repeated gingival swelling of the affected primary teeth determined and recommended extraction of the involved teeth by previous dentists. In the permanent teeth, repeated swelling was only reported in one case (case A4). All teeth included in this study required possible root canal treatment without severe root resorption and in the case of primary teeth no early physiological exfoliation was expected.

Table 1. Summary of cases of perforated primary teeth.

Case number	Age at operation	Gender	Tooth location	Follow-up period (months)	Results
C1	6Y0M	F	$\underline{\text{D}}$	30	Spontaneously exfoliated and permanent successor found emerging at 8Y6M
C2	6Y6M	F	$\overline{\text{D}}$	25	Spontaneously exfoliated and permanent successor found emerging at 8Y7M
C3	9Y6M	M	$\underline{\text{E}}$	20	Spontaneously exfoliated and permanent successor found emerging at 11Y2M
C4	5Y7M	M	$\overline{\text{D}}$	16	Spontaneously exfoliated and permanent successor found emerging at 6Y11M
C5	8Y5M	M	$\overline{\text{E}}$	15	Spontaneously exfoliated and permanent successor found emerging at 9Y8M
C6	8Y8M	M	$\underline{\text{D}}$	20	Extraction performed at 10Y4M due to eruption of permanent successor
C7	7Y8M	M	$\underline{\text{D}}$	4	Extraction performed at 8Y0M due to eruption of permanent successor
C8	4Y11M	M	$\overline{\text{D}}$	17	No abnormal signs or symptoms observed until 6Y4M
C9	8Y5M	F	$\underline{\text{E}}$	15	No abnormal signs or symptoms observed until 9Y8M
C10	6Y4M	F	$\overline{\text{E}}$	12	No abnormal signs or symptoms observed until 7Y4M
C11	5Y9M	M	$\overline{\text{D}}$	7	No abnormal signs or symptoms observed until 6Y4M
C12	7Y1M	M	$\underline{\text{D}}$	12	Interruption of treatment at 8Y1M without abnormal signs or symptoms observed
C13	8Y5M	F	$\underline{\text{E}}$	12	Interruption of treatment at 9Y5M without abnormal signs or symptoms observed

Table 2. Summary of cases of perforated permanent teeth.

Case number	Age at operation	Gender	Tooth location	Follow-up period (months)
A1	58Y11M	M	$\underline{4}$	60
A2	35Y6M	F	$\underline{5}$	57
A3	35Y3M	F	$\overline{6}$	36
A4	46Y5M	M	$\overline{1}$	21
A5	69Y10M	F	$\overline{5}$	17
A6	57Y6M	M	$\overline{7}$	17
A7	67Y10M	F	$\underline{5}$	12
A8	37Y6M	M	$\underline{6}$	10

Treatment procedures

After local anesthesia and rubber dam placement, filling materials or food debris causing sealing of the cavity area was removed, and the presence of a perforated lesion was confirmed. Next, a debridement procedure and coagulation was performed using an electric knife (Best Surge; Gebruder Martin GmbH & Co. KG, Frondenberg, Germany). An atelocollagen sponge (TERUPLUG™, Olympus Terumo Biomaterials Corp., Tokyo, Japan) derived from bovine skin and containing a combination of type 1 and type 3 collagen was then cut to an appropriate size to fit the perforated region and pushed into the surface of the debrided area, followed by temporary sealing (Hy-Bond Carbo Cement Shofu Inc., Japan). At the first three month follow up with no adverse reactions, composite resin or stainless-steel crown restorations were carried out for primary teeth, while final full cover restorations following a metal core build-up were performed for the permanent teeth.

Figure 1 shows a representative case (C5) of a maxillary left primary first molar with cervical root perforation in a boy aged 8 years 5 months. Atelocollagen was prepared by

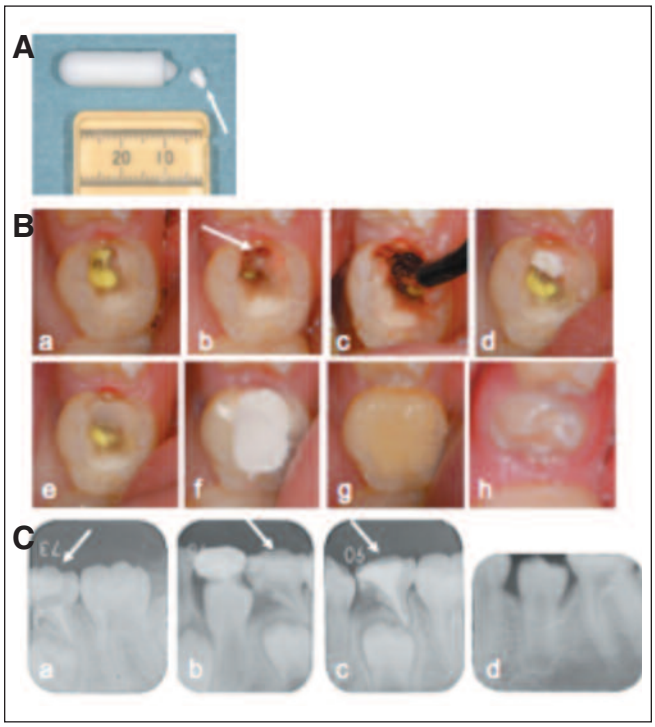

Figure 1. Application of atelocollagen for the maxillary left first primary molar with cervical root perforation in a boy aged 8 years 5 months (case C5). (A) Atelocollagen sponge material. (B) Operation procedures. (C) Periapical radiographs.

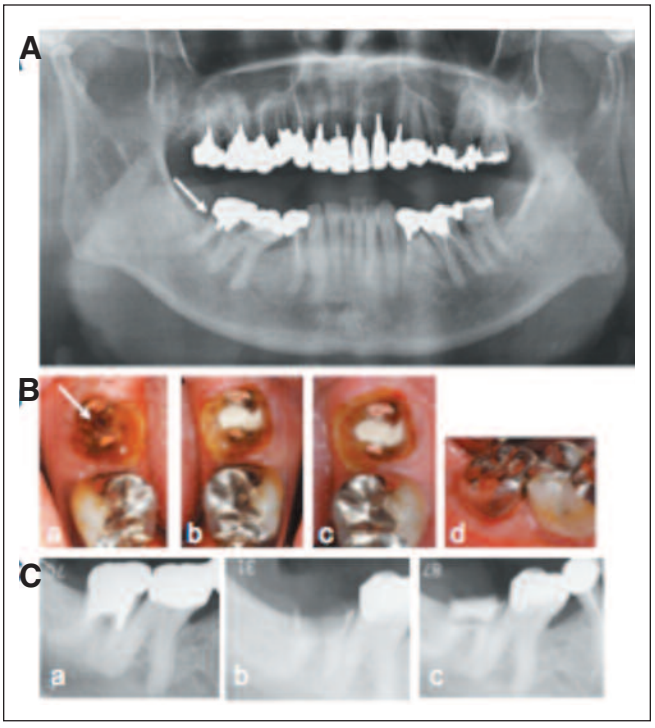

Figure 2. Application of atelocollagen for the mandibular right second molar with furcal root perforation in a man aged 57 years (case A6). (A) Orthopantomograph taken at the first visit. (B) Operation procedures. (C) Periapical radiographs.

cutting the sponge material to fit the perforation area (arrow in panel A). Panel B shows the operation procedures from the first visit (a). Removal of a cement filling and root canal filling materials revealed a cervical root perforation (arrow in B-b). Root canal irrigation and filling were performed, and the granulation tissue in the perforated area was debrided done with an electric knife (B-c). Application of atelocollagen into the perforated area (B-d) and sealing with composite resin were performed (B-e). Finally, a temporary filling was filled with cement (B-f) and a composite resin restoration was performed after confirmation of good tooth conditions (B-g). The maxillary left first premolar emerged into the oral cavity 1 year 3 months later (B-h). Panel C shows periapical radiographs taken at the first visit (C-a), after removal of the cement filling and root canal filling materials (C-b), just after the root canal irrigation, root canal filling, debridement, and atelocollagen application in the perforated area (C-c), and when the permanent successor emerged into the oral cavity 1 year 3 months later (C-d). The arrows indicate the affected tooth.

Figure 2 shows a representative case (A6) of a mandibular right second molar with furcal root perforation in a man aged 57 years. Panel A shows an orthopantomograph taken at the first visit, with the arrow indicating the affected tooth. Panel B shows the clinical procedure, in which removal of a full cast crown and post core revealed a cervical root perforation (arrow in B-a). Thereafter, debridement of the granulation tissue was performed (B-b). Another image was obtained at 1 week after the clinical procedure (B-c), and a full cast crown was applied 1 month after (B-d). Panel C shows periapical radiographs taken prior to treatemtn(C-a), after removal of the full cast crown and post core (C-b), and just after finishing the procedure (C-c).

Clinical examinations

All the clinical examinations were carried out by a single skilled examiner (KM). Clinical signs and symptoms, such as chewing, percussion pain, tenderness, and gingival inflammation, were checked at three months intervals. In addition, radiographic examinations were performed to compare the findings for the perforated lesion with those from previous examinations.

RESULTS

Table 1 summarizes the 13 cases of perforated primary teeth, all of which were primary first and second molars (C1-C13), with a representative case (C5) shown in Figure 1. All the cases showed good clinical results, with spontaneous exfoliation followed by eruption of the permanent successors noted in five cases (C1-C5) and extraction in two cases to facilitate the eruption of premolars (C6 and C7). Four cases were followed waiting for eruption of the permanent successors (C8-C11). Periodic observations in the remaining two cases (C12 and C13) could not be followed extensively due to patients moved to different communities, however, no abnormal signs or symptoms were observed at their last visit.

Table 2 summarizes the 8 cases of perforated permanent teeth (A1-A8), with a representative case (A6) shown in Figure 2. The affected teeth were one incisor, four premolars,

and two molars, and the follow-up periods for these cases ranged from 10 to 60 months. Full cover crowns were done to all teeth after root canal treatment, with atelocollagen application. None of the cases showed any abnormal signs or symptoms up to the last exam.

DISCUSSION

We used a novel approach for the treatment of furcal and cervical perforated teeth. This method involving debridement of the perforated area followed by atelocollagen application was found to be effective. Generally, these patients visited the clinic with the chief complaint of repeated abscess formation in the area of the affected molars, for which previous dentists recommended extraction. Based on previous experience with applications of composite resin, the prognosis of these cases was poor, owing to the technical difficulties associated with application of resin to the perforated locations. However, since we had applied successfully atelocollagen materials to extraction sockets in several cases, we developed a method for the application of atelocollagen to the perforated areas. Under local anesthesia, thorough debridement procedures to remove the infected granulation tissue are important before applying atelocollagen sponge in the perforated area.

Following the success in those cases, we decided to apply the method for additional cases with furcal and cervical root perforation, which would otherwise probably have resulted in tooth extraction. Early exfoliation of the affected primary teeth occurred in case C1, indicating that a pre-existing infection or resorption may affect the early eruption of the permanent successors. This point should be considered in subsequent studies.

We believe that the present novel method is more effective for primary teeth, since preservation for only a limited period until eruption of the permanent successors was adequate. In the 13 child cases analyzed, there were no problems before the permanent successors erupted. Although there are no reports of evaluation of other methods utilized to treat similar conditions related to perforated primary teeth, we consider that this novel approach could be an available effective treatment modality for this condition.

Of the 8 cases of permanent teeth (A1-A8), most showed good clinical results during observation periods that ranged from 10 to 60 months and consisted of repeated recall examinations at 3-month intervals. Unlike primary teeth, in which good results are only required for a limited period until the permanent successors erupt, much longer periods of observation may be required for cases of permanent teeth before we can propose that the present approach is widely introduced.

Nevertheless, the good results observed for the present primary teeth and permanent teeth and cervical and furcal perforation repairs lead us to speculate that there is a high probability of good long term results.

Takenaka *et al*[12] reported that an apatite-collagen composite has benefits for restoring the structure and biological functions of damaged bone tissue, since both apatite and collagen are primary components of bone. They attempted to apply that composite material for the recovery of defects in root canals. In the present study, we used atelocollagen as a physical barrier, although we speculate that bone formation could occur in the perforated area. Further studies focusing on histopathological analyses of this method are needed.

CONCLUSIONS

In summary, we successfully applied atelocollagen to perforated primary teeth using a novel method. The method used in this study enabled preservation of the affected teeth, to maintain the space for the permanent successors.

Successful application was also shown in permanent teeth with cervical and furcal perforations.

ACKNOWLEDGMENTS

This study was suppported by Osaka University Graduate School of Dentistry. We thank Olympus Terumo Biomaterials Corp., Tokyo, Japan, for providing the atelocollagen sponge material.

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