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Clinical and Radiographic Findings Outcomes of Cases Managed with Lesion Sterilization and Tissue Repair (LSTR) in Pediatric Patients with Periapical Abscesses of Primary Teeth

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Abstract: Background: Periapical abscesses of primary teeth are a common reason for emergency pediatric dental visits and a clinically challenging entity in children whose cooperation, anatomy, and developing permanent successors all constrain treatment choices. Lesion Sterilization and Tissue Repair (LSTR), a non-instrumental endodontic approach using a triple antibiotic combination, has been proposed as a minimally invasive alternative to conventional pulpectomy in such cases. Aim: To describe the clinical and radiographic findings of pediatric patients aged 2–11 years presenting with periapical abscesses of primary teeth, and to report the outcomes of the subset of cases managed with LSTR. Materials and methods: A retrospective chart review of 79 children aged 2–11 years (mean 6.25 ± 1.87) with a clinical and/or radiographic diagnosis of periapical abscess of a primary tooth was conducted. Demographic data, chief complaint, symptom duration, jaw and tooth distribution, parental/caregiver oral-hygiene practice, radiographic appearance, treatment modality (including LSTR), follow-up, and post-treatment relapse were recorded. Categorical associations with age (≤5 years vs. ≥6 years) and gender were tested using Fisher's exact test, with significance set at $P < 0.05$. Results: The sample comprised 33 males (41.77%) and 46 females (58.23%); 35 children (44.30%) were ≤5 years and 44 (55.70%) were 6 years or older. Mandibular teeth (56.96%) and primary first/second molars accounted for the majority of affected teeth. The chief complaint distribution was significantly associated with age ($P = 0.047$), as were caregiver oral-hygiene practice ($P < 0.001$) and the pattern of radiographic findings ($P < 0.001$). LSTR was performed in 12 of the 79 cases (15.19%), with no significant association between use of LSTR and either age ($P = 0.666$) or gender ($P = 0.530$). Post-treatment relapse following restoration was uncommon (5.06% with mild and 7.59% with moderate findings) and showed a significant gender association ($P = 0.046$). Conclusion: In this pediatric cohort, periapical abscesses of primary teeth predominantly affected mandibular molars, were strongly associated with poor caregiver-supported oral-hygiene practice, and were accompanied by readily identifiable radiographic changes. LSTR was used selectively and was followed by an acceptably low rate of clinical relapse, supporting its role as a conservative option in carefully chosen cases. Larger prospective studies with standardized success criteria are needed.

Keywords: Primary teeth; Periapical abscess; Pediatric dentistry; Lesion sterilization and tissue repair; LSTR; Retrospective study.

Introduction

Dental caries remains the most prevalent chronic disease of childhood, and its untreated progression in primary teeth is the principal pathway to pulp necrosis and periapical abscess formation in young children[1][2]. A periapical abscess in a primary tooth is more than a localized infection: because of the close anatomical relationship between the root apices of deciduous molars and the developing permanent tooth germ, periapical inflammation can disturb enamel formation, alter the eruption pattern, or in rare but well-documented cases provoke systemic complications[3][4][5]. Premature loss or extraction of an abscessed primary molar may also produce loss of arch length, drifting of adjacent teeth, and orthodontic sequelae that persist into the permanent dentition[6][7].

The therapeutic choice for an abscessed primary molar is constrained by several biological and behavioral factors that are unique to the pediatric patient. The complex, ribbon-shaped morphology of primary root canals, accessory canals, and progressive physiologic root resorption make complete chemo-mechanical debridement difficult and unpredictable[8][9]. Limited cooperation, especially in preschoolers, restricts the time available for instrumentation and the use of long, multi-visit protocols[10][11]. As a result, conventional pulpectomy although effective in many series is not always feasible, and its outcomes vary considerably across studies[12][13][14].

Lesion Sterilization and Tissue Repair (LSTR), introduced by the Cariology Research Unit of the Niigata University School of Dentistry, was developed to address precisely these limitations[15][16]. The technique is based on the concept that the lesion itself—caries, infected pulp tissue, and the surrounding inflamed periapical bone—can be "sterilized" by topical application of a combination of antibacterial drugs, allowing the host to repair the damaged tissues without the need for thorough mechanical instrumentation[17][18][19]. The original "3Mix" formulation contains ciprofloxacin ,metronidazole, , and clyndamycin, often delivered in a macrogol-propylene glycol vehicle (3Mix-MP)[20][21][22]. Several modifications have been proposed, including replacement of minocycline with clindamycin to avoid tooth discoloration, and the addition of statins or chloramphenicol/tetracycline/zinc-oxide pastes (CTZ)[23][24][25].

The published evidence on LSTR in primary teeth is encouraging but heterogeneous. In vivo studies and randomized trials have reported clinical success rates ranging from approximately 70% to over 95% in necrotic or abscessed primary molars, with radiographic success generally trailing clinical success by 5–15 percentage points[26][27][28]. Systematic reviews and meta-analyses have concluded that LSTR is at least non-inferior to conventional pulpectomy in clinical terms, while offering shorter chair-time, fewer visits, and a lower technique-sensitivity threshold[29][30][31]. Reported failure modes include persistent or recurrent sinus tract, internal/external resorption, premature mobility, and radiographic enlargement of the periapical lesion[32][33][34]. Patient cooperation, parental compliance, and the quality of the coronal seal have repeatedly been identified as decisive determinants of outcome[35][36][37].

Despite this growing body of clinical literature, much of the published data come from controlled trials in tertiary referral settings, and there is comparatively little information describing the day-to-day clinical and radiographic profile of children who present with periapical abscesses of primary teeth in routine pediatric dental practice, including the proportion in whom LSTR is selected and how those cases evolve over follow-up[38][39][40]. Filling this descriptive gap is important: it informs case selection, parental counselling, and service planning, and it provides a baseline against which prospective interventional studies can be compared.

The aims of the present retrospective study were therefore: (i) to describe the demographic, clinical, and radiographic characteristics of pediatric patients aged 2–11 years presenting with a periapical abscess of one or more primary teeth; (ii) to examine whether these characteristics differed by age group (≤5 years vs. ≥6 years) and by gender; and (iii) to describe the use and short-term outcomes including relapse after restoration of the subset of cases managed with LSTR.

Methodology

Study design and setting

This was a retrospective, single-center observational study based on the clinical records of pediatric patients who attended the pediatric dental clinic for management of periapical abscesses of primary teeth. The study was conducted in accordance with the Declaration of Helsinki and approved by the institutional research ethics committee. Because the analysis used existing, de-identified clinical records, the requirement for individual informed consent was waived; consent for treatment had been obtained at the time of the original visit from the parent or legal guardian of each child.

Eligibility criteria

Children were eligible for inclusion if they (i) were aged between 2 and 11 years at the time of presentation; (ii) had at least one primary tooth diagnosed with a periapical abscess on the basis of clinical examination (presence of intra-oral or extra-oral swelling, sinus tract, sensitivity to percussion, mobility beyond physiologic, or pain on biting) and/or radiographic examination (widening of the periodontal ligament space, loss of lamina dura, periapical or furcation radiolucency); and (iii) had a complete set of baseline clinical and radiographic records available. Children with systemic conditions known to alter pulpal or periapical healing (e.g., uncontrolled diabetes, immunodeficiency, syndromic conditions affecting tooth development), those with primary teeth presenting with non-restorable crowns scheduled directly for extraction, and those with incomplete records were excluded[41].

Data collection

The following variables were extracted from the clinical chart and the radiographs of each eligible patient and entered into a structured data sheet: age (in years, and dichotomized as ≤5 years vs. ≥6 years to reflect the typical transition between pre-school and early school age in pediatric dental management); gender; chief complaint at presentation (categorized as pain, swelling/sinus tract, or combined/other); duration of symptoms before presentation (categorized as recent, intermediate, or prolonged); affected jaw (maxilla vs. mandible); affected tooth type (primary first molar, primary second molar, primary canine, or primary incisor); radiographic appearance of the lesion (periapical radiolucency vs. furcation radiolucency vs. combined or extensive bone changes); treatment modality, including whether LSTR was used; number of follow-up visits; and presence and severity of clinical or radiographic relapse after definitive restoration. The category labelled "caregiver-supported oral-hygiene practice" was recorded as adequate or inadequate on the basis of the chart-documented brushing and dietary supervision provided by the parent or carer.

LSTR protocol

When LSTR was selected as the treatment modality, the procedure followed an established 3Mix-MP protocol broadly consistent with the technique described by Takushige et al. and subsequently refined by several authors[42]. After local anesthesia and rubber-dam isolation when feasible, caries was removed, the pulp chamber was accessed, and gross necrotic tissue was gently evacuated without instrumentation of the root canals. The cavity was irrigated and dried, and a freshly prepared paste of ciprofloxacin, metronidazole, , and clindamycin at a ratio of 1:3:3 recpectivly in a macrogol-propylene glycol vehicle was placed over the canal orifices and pulp chamber floor. The access cavity was sealed with a glass-ionomer cement base and restored with a stainless-steel crown or a definitive restoration at a subsequent visit, depending on cooperation and remaining tooth structure[43].

Outcome definitions

Clinical relapse was defined, at any follow-up, as the recurrence of pain, swelling, sinus tract, abnormal mobility, or persistent tenderness on percussion. Radiographic relapse was defined as the appearance of a new periapical or furcation radiolucency, or measurable enlargement of a pre-existing lesion. "Mild" relapse referred to localized clinical or radiographic signs not requiring

extraction, while "moderate" relapse referred to findings that prompted retreatment or extraction of the affected tooth[44].

Statistical analysis

Data were analyzed using a standard statistical software package. Descriptive statistics (frequencies and percentages for categorical variables; means and standard deviations for continuous variables) were calculated. The associations between each categorical variable and (a) age group and (b) gender were tested using Fisher's exact test, which was preferred over the chi-square test because of the presence of expected cell counts below five in several cross-tabulations. A two-tailed P-value of less than 0.05 was considered statistically significant.

Results & Discussion

Sample characteristics

A total of 79 pediatric patients met the inclusion criteria as shown in Figure 1. The mean age was 6.25 ± 1.87 years (range 2–11 years). The cohort comprised 33 males (41.77%) and 46 females (58.23%). Thirty-five children (44.30%) were aged 5 years or younger and 44 (55.70%) were 6 years or older (Table 1).

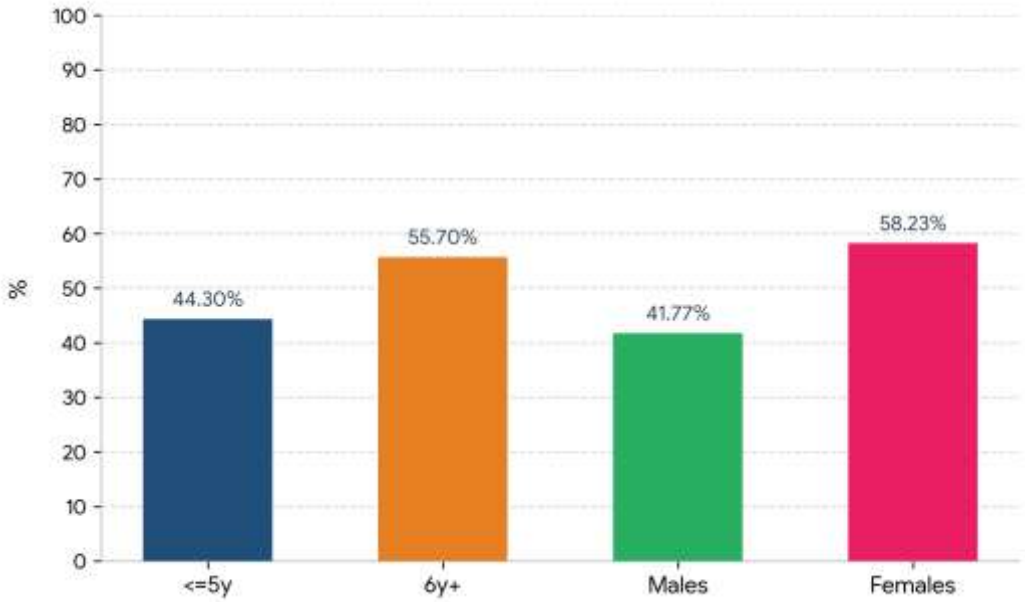

Figure 1. Bar chart represents subjects' distribution by age and gender (n = 79).

Table 1. Distribution of subjects by age and gender (n = 79).

Variable	Category	N	%
Age	≤ 5 years	35	44.30
	≥ 6 years	44	55.70
Gender	Males	33	41.77
	Females	46	58.23

Clinical and radiographic profile

Pain alone was the chief complaint in 12.66% of children, swelling and/or sinus tract in 29.11%, and a combined presentation (pain plus swelling or pain plus a draining sinus tract) was the most frequent presentation, accounting for 58.23% of cases. Symptoms had been present for less than one week in approximately 79.75% of children, between one and four weeks in 17.72%, and for more than four weeks in 2.53%. The mandible was affected more frequently than the maxilla

(56.96% vs. 43.04%). The most commonly affected teeth were the primary second molars (51.90%) and the primary first molars (43.04%), with primary canines (1.27%) and incisors (3.80%) representing the minority of cases a distribution consistent with previous radiographic surveys of the primary dentition.

Radiographically, 64.56% of children showed a periapical or furcation radiolucency confined to the affected tooth, while 35.44% presented with more extensive bony changes such as loss of lamina dura combined with widening of the periodontal ligament space, internal or external resorption, or destruction of the inter-radicular bone. Caregiver-supported oral-hygiene practice was judged adequate in only 22.78% of children and inadequate in 77.22%.

Treatment, follow-up, and relapse

LSTR was used as the primary endodontic approach in 12 children (15.19%), while the remaining 67 (84.81%) were managed with conventional pulpectomy, pulpotomy, or, when indicated, extraction. Sixty-two children (78.48%) had no documented relapse during follow-up, 10 (12.66%) were seen for at least one short follow-up only, and 7 (8.86%) had longer or repeated follow-up. After definitive restoration, no clinical or radiographic relapse was recorded in 87.34% of cases; 5.06% showed mild relapse and 7.59% showed moderate relapse requiring further intervention.

Associations with age group

Three variables showed a statistically significant association with age group (Table 2). Children aged ≤5 years were over-represented among those whose chief complaint was pain alone (80.00% of "pain only" cases were ≤5 years, P = 0.047) and among those with adequate caregiver-supported oral-hygiene practice (only 5.56% of children with adequate practice were ≤5 years vs. 94.44% who were ≥6 years; P < 0.001), reflecting the developmental shift towards self-brushing in older children. The radiographic pattern also differed significantly between age groups (P < 0.001) with extensive lesions more common in older children. There was no significant association between age and the duration of symptoms, follow-up status, jaw or tooth distribution, the use of LSTR, or relapse after restoration (all P > 0.05).

Table 2. Association between studied variables and age group (≤5 years vs. ≥ 6 years), Fisher's exact test.

Variable	Category	<5y n (%)	≥6y n (%)	Fisher	P
Chief complaint	Pain only	8 (80.00)	2 (20.00)	6.007	0.047*
	Swelling/sinus	10 (43.48)	13 (56.52)		
	Combined	17 (36.96)	29 (63.04)		
Duration	< 1 week	26 (41.27)	37 (58.73)	2.577	0.255
	1-4 weeks	7 (50.00)	7 (50.00)		
	> 4 weeks	2 (100.00)	0 (0.00)		
Follow-up	None/single	25 (40.32)	37 (59.68)	5.142	0.081
	Short	4 (40.00)	6 (60.00)		
	Repeated	6 (85.71)	1 (14.29)		
Jaw	Maxilla	16 (47.06)	18 (52.94)	0.184	0.668
	Mandible	19 (42.22)	26 (57.78)		
LSTR	Yes	6 (50.00)	6 (50.00)	0.186	0.666
	No	29 (43.28)	38 (56.72)		
Caregiver OH practice	Adequate	1 (5.56)	17 (94.44)	14.184	<0.001*
	Inadequate	34 (55.74)	27 (44.26)		
Relapse after restoration	None	30 (43.48)	39 (56.52)	0.379	0.999
	Mild	2 (50.00)	2 (50.00)		
	Moderate	3 (50.00)	3 (50.00)		
Tooth	1st primary molar	15 (44.12)	19 (55.88)	2.021	0.655
	2nd primary	17 (41.46)	24 (58.54)		

	molar				
	Primary canine	1 (100.00)	0 (0.00)		
	Primary incisor	2 (66.67)	1 (33.33)		
Radiographic finding	Localized	2 (7.14)	26 (92.86)	24.273	<0.001*
	Extensive	33 (64.71)	18 (35.29)		

* Significant at $p < 0.05$.

Associations with gender

When the same variables were cross-tabulated against gender, only one comparison reached statistical significance (Table 3): relapse after restoration was distributed unequally between males and females (P = 0.046), with all four cases of mild relapse occurring in males. None of the other variables chief complaint, duration of symptoms, follow-up category, jaw, tooth, caregiver oral-hygiene practice, use of LSTR, or radiographic appearance showed a significant gender association (all P > 0.05).

Table 3. Association between studied variables and gender, Fisher's exact test.

Variable	Category	Males n (%)	Females n (%)	Fisher	P
Chief complaint	Pain only	3 (30.00)	7 (70.00)	1.679	0.467
	Swelling / sinus	12 (52.17)	11 (47.83)		
	Combined	18 (39.13)	28 (60.87)		
Duration	< 1 week	24 (38.10)	39 (61.90)	2.027	0.412
	1-4 weeks	8 (57.14)	6 (42.86)		
	> 4 weeks	1 (50.00)	1 (50.00)		
Follow-up	None/single	24 (38.71)	38 (61.29)	1.682	0.463
	Short	6 (60.00)	4 (40.00)		
	Repeated	3 (42.86)	4 (57.14)		
Jaw	Maxilla	15 (44.12)	19 (55.88)	0.135	0.713
	Mandible	18 (40.00)	27 (60.00)		
LSTR	Yes	6 (50.00)	6 (50.00)	0.394	0.530
	No	27 (40.30)	40 (59.70)		
Caregiver OH practice	Adequate	5 (27.78)	13 (72.22)	1.877	0.171
	Inadequate	28 (45.90)	33 (54.10)		
Relapse after restoration	None	26 (37.68)	43 (62.32)	5.894	0.046*
	Mild	4 (100.00)	0 (0.00)		
	Moderate	3 (50.00)	3 (50.00)		
Tooth	1st primary molar	13 (38.24)	21 (61.76)	3.583	0.213
	2nd primary molar	19 (46.34)	22 (53.66)		
	Primary canine	1 (100.00)	0 (0.00)		
	Primary incisor	0 (0.00)	3 (100.00)		
Radiographic finding	Localized	13 (46.43)	15 (53.57)	0.387	0.534
	Extensive	20 (39.22)	31 (60.78)		

* Significant at $p < 0.05$.

Discussion

This retrospective analysis describes the clinical and radiographic profile of 79 children aged 2–11 years presenting with periapical abscesses of primary teeth, and reports the short-term outcomes of the subset managed with LSTR. Three findings deserve emphasis: the dominance of mandibular primary molars among the affected teeth, the strong association between caregiver-supported oral-hygiene practice and patient age, and the acceptably low rate of clinical relapse after definitive restoration in cases that included LSTR.

Clinical and radiographic pattern

The predominance of primary molars and particularly mandibular molars among teeth presenting with periapical abscess is consistent with previous cross-sectional and radiographic surveys[45][46][47]. Primary molars carry the bulk of occlusal load in the mixed dentition, are more susceptible to occlusal and proximal caries, and have anatomical features (broad pulp horns, accessory canals, thin furcal floor) that allow rapid extension of pulpal infection towards the furcation and periapex[48][49][50]. The high proportion of children presenting with combined pain and swelling (58.23%) and the short median duration of symptoms before presentation (less than one week in approximately 80% of cases) suggest that, in this cohort, parents tended to seek dental care relatively promptly once external signs of infection appeared, but only after symptoms were already advanced a pattern repeatedly observed in pediatric emergency dentistry[51][52].

The radiographic findings a localized periapical or furcation radiolucency in roughly two-thirds of cases and more extensive bony changes in the remaining third fall within the range described by Aminabadi, Morankar, Goyal for primary molars indicated for pulpectomy or extraction. The strong association between extensive radiographic findings and age group ($P < 0.001$), with extensive lesions concentrated in the older children (≥6 years), likely reflects the longer time during which carious lesions have progressed before the child reaches school age, and the cumulative effect of repeated cariogenic challenges.

Caregiver oral-hygiene practice

The most striking demographic association in this study was between age group and caregiver-supported oral-hygiene practice. Adequate parental supervision of brushing and dietary habits was documented in only 22.78% of children overall and was much more frequent in older children (≥6 years) than in preschoolers ($P < 0.001$). This finding is paradoxical only at first glance: it does not mean that older children received better care than preschoolers throughout life. Rather, in routine pediatric practice, older children are more often credited with "adequate" hygiene because they brush themselves under intermittent supervision, whereas preschoolers depend almost entirely on parental performance and chart-documented parental performance was, in this cohort, frequently inadequate. The implication for prevention is clear and aligns with previous reports linking parental literacy, social class, and supervision to early childhood caries and its sequelae: any clinical pathway that includes LSTR must be embedded in a structured caregiver-counselling component, since the success of the technique depends as much on the post-treatment oral environment as on the antibacterial paste itself.

LSTR: rationale, use, and outcomes

LSTR was used in 15.19% of cases. The decision to apply LSTR rather than conventional pulpectomy was driven, in this cohort, by considerations that mirror those reported in the literature: limited cooperation in younger children, complex root anatomy precluding adequate instrumentation, advanced physiologic resorption, the presence of a sinus tract with otherwise restorable crown structure, and the desire to avoid extraction of a strategically important primary molar before its physiologic exfoliation. The biological rationale for LSTR broad-spectrum antibacterial sterilization of the lesion combined with preservation of any remaining vital pulp tissue and an undisturbed periapical environment is supported by microbiological studies showing that the 3Mix combination is active against the obligate anaerobes most commonly isolated from infected primary canals, and by histological evidence of periapical bone repair following its

use[53].

Reported success rates for LSTR in primary teeth range broadly across designs and follow-up durations, but most well-conducted in vivo studies and meta-analyses converge on a clinical success of approximately 80–95% and a radiographic success of approximately 70–90% at follow-up periods of 6 to 36 months[54]. Direct comparisons with conventional pulpectomy generally show no statistically significant clinical superiority for either technique, although LSTR offers advantages in chair time, number of visits, and applicability in uncooperative or anatomically challenging cases[55]. In the present cohort, no clinical or radiographic relapse was documented in 87.34% of cases overall, with mild relapse in 5.06% and moderate relapse in 7.59%; the absence of a statistically significant association between LSTR use and either age ($P = 0.666$) or gender ($P = 0.530$) suggests that, when LSTR was selected, it was applied across the full pediatric age range and to both sexes, and that the relapse pattern was not driven by these demographic factors.

Gender and relapse

The only gender-related finding to reach statistical significance was the distribution of relapse after restoration ($P = 0.046$), with all four mild relapses occurring in males. With such small numbers (only 10 relapses in total) this association must be interpreted cautiously: it could reflect a genuine behavioral or biological difference (e.g., differences in dietary habits, snacking frequency, or restoration handling), but it is at least equally likely to be a chance finding inflated by multiple comparisons. Larger, prospectively designed cohorts will be needed before any gender-specific recommendation can be issued[56][57][58].

Strengths and limitations

The main strength of this study is its description of a real-world pediatric cohort, in which inclusion was not biased by the strict eligibility criteria of an interventional trial; all consecutive children with periapical abscesses of primary teeth in the study period were considered, and the analysis describes both the LSTR subgroup and the broader population from which it was drawn. The use of Fisher's exact test was appropriate given the sparse cell counts in several cross-tabulations.

The study has several limitations that must be acknowledged. First, the retrospective design precludes any causal inference: the associations described here are descriptive, not explanatory. Second, the sample size ($n = 79$) and, in particular, the LSTR subgroup ($n = 12$) limit statistical power, especially for outcomes with low event rates such as relapse; subgroup tests should be regarded as hypothesis-generating. Third, multiple Fisher's exact tests were performed without formal adjustment for multiple comparisons, which inflates the probability of at least one false-positive finding; the two strongest associations (caregiver oral-hygiene practice and radiographic findings versus age) would survive a Bonferroni-style correction, but the marginal associations (chief complaint versus age, gender versus relapse) would not. Fourth, success and relapse were defined on the basis of chart documentation rather than blinded, standardized clinical and radiographic examinations, and inter-examiner reliability was not formally assessed[59]. Fifth, follow-up duration varied between patients and was generally short relative to the time horizon required to assess true LSTR success physiologic exfoliation of primary molars and eruption of permanent successors. Sixth, the categorical coding of variables (such as caregiver oral-hygiene practice and chief complaint) involved a degree of clinical judgement that is inherent to retrospective chart review. Finally, the analysis is based on a single centre, which limits external validity to settings with a similar case mix and clinical protocol.

These limitations notwithstanding, the broad pattern reported here mandibular molar predominance, a strong link between age and caregiver-supported hygiene, and an acceptably low short-term relapse rate after treatment that included LSTR is consistent with the published literature on both abscessed primary teeth and LSTR therapy[60]. Future work should focus on prospective, multi-center cohorts with predefined success criteria and longer follow-up; on the comparative effectiveness of different LSTR formulations (3Mix, 3Mix-MP, modified 3Mix-Simvastatin, CTZ paste)[61]; and on the integration of LSTR into preventive care pathways that explicitly target caregiver behavior[62].

Conclusion

Within the limitations of this retrospective single-center study, periapical abscesses of primary teeth in children aged 2–11 years predominantly involved mandibular molars, were strongly associated with inadequate caregiver-supported oral-hygiene practice, and were accompanied by readily identifiable radiographic changes whose extent increased with age. LSTR was selected in approximately one in six cases on the basis of cooperation, anatomy, and case-specific clinical judgement, and was followed by a low rate of clinical relapse during follow-up. These findings support the cautious, selective use of LSTR as part of a comprehensive pediatric endodontic algorithm, while underlining the need for adequately powered, prospective studies with standardized outcome criteria to define its precise place among the management options for the abscessed primary tooth.

Declarations

Funding: This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest: The authors declare that they have no conflicts of interest.

Ethical approval: The study protocol was reviewed and approved by the institutional research ethics committee, and conducted in accordance with the Declaration of Helsinki.

Data availability: The de-identified data supporting the findings of this study are available from the corresponding author on reasonable request.

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