

## MINI-REVIEW

# Retained deciduous teeth: the epidemiology, etiology and treatment plans

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**Abstract**

Retained deciduous teeth (RDT), also known as persistent primary teeth, are commonly observed in children and adolescents. They frequently present in clinical settings, yet there is a lack of comprehensive summaries on this condition. Therefore, this review aims to summarize the epidemiology and etiology of RDT, provide recommendations for treatment and potential prevention, and increase awareness of this condition among dentists and the general public. The prevalence of RDT has risen in recent years, attributed to poor oral habits such as reduced mastication due to the consumption of softer foods, with the highest reported prevalence being 59.8%. The etiologies of RDT include ectopic tooth eruption, developmental issues, dental caries, apical periodontitis, genetic diseases and lifestyle habits. Factors such as race, gender and geographic regions also contribute to its prevalence. If not addressed properly, RDT can have adverse effects on physical and mental health. The treatment plan for RDT depends on whether a permanent tooth is inherited, whether the permanent tooth is positioned correctly, and the patient's age. Given the scarce reports on RDT, this narrative review is based on limited literature and clinical experience. Future studies should focus on the etiology and large-scale epidemiology of RDT to improve the overall welfare of children affected by this condition.

**Keywords**

Retained deciduous teeth; Craniofacial development; Deciduous tooth; Oral health

## 1. Introduction

Retained deciduous teeth (RDT), also known as retained baby teeth or persistent primary teeth, are primary teeth that remain in the mouth beyond their normal exfoliation period [1]. These are baby teeth that persist when the permanent teeth are expected to emerge [2]. The concept of a retained tooth differs from that of an impacted tooth, as the former typically refers to a tooth that continues to stay in the mouth when it is expected to exfoliate, while the latter usually refers to a tooth abnormally stuck in the bone. A primary tooth can be either retained or impacted, whereas a permanent tooth can only be impacted since it has no successor. The pathological phenomenon of RDT is also referred to as “two rows of teeth” or “shark teeth”, indicating that the permanent teeth have erupted but the primary teeth have not yet naturally fallen out. Normally, primary incisors begin to shed around the age of 6 or 7 years, when the permanent teeth start to erupt and push the primary teeth out of their way [3]. This period, typically lasting until the age of 12 or 13 years, is known as the mixed dentition stage. At the end of this stage, all primary teeth should be replaced by permanent teeth, marking the transition to permanent dentition. The presence of primary teeth is essential for the development and guidance of permanent teeth eruption, as they serve as “the best natural space maintainer” [4]. Primary teeth enable

children to chew properly, speak clearly, maintain a normal bite and promote proper facial development. Laverty *et al.* [5] suggested that parents should closely monitor the shedding of primary teeth and be alert if a permanent tooth does not emerge within six months after its contralateral homonymous tooth on the same arch has erupted or if its own permanent successor is delayed by more than one year. Another indicator for intervention is when the deciduous teeth are still present for more than approximately four months after the contralateral homonymous tooth has already been replaced [6]. This is based on the observation that there is usually little difference in the timing of eruption between the left and right sides of the same arch [7]. If RDT is not properly managed, it may increase the risk of malocclusion, dental caries and periodontal disease, along with associated complications due to its persistence and the susceptibility to caries bacteria because of its tissue structure. Clinically, an increasing number of pediatric patients are presenting with RDT, finding that reduced mastication caused by the consumption of softer food may be one of the reasons. RDT is frequently observed in the clinic, but comprehensive summaries of this condition are limited. This narrative review aims to summarize the epidemiology and etiology of RDT, provide recommendations for its treatment and prevention, raise awareness of this condition among dentists and the public,

and promote a confident and fulfilling life for patients with RDT.

## 2. The epidemiology of RDT

The presence of RDT has been reported worldwide. In Indore, the reported RDT rate is 12.8% among 500 patients from the Department of Pediatric and Preventive Dentistry [8]. In Iran, a study indicated that approximately 20.85% of children experience prolonged retention of primary teeth, with the highest occurrence observed in 10-year-old children [9]. In Naples, a city in Italy, the presence of RDT is documented at 16.5% in patients with compound/complex odontomas [10]. In China, the prevalence of RDT among adolescents aged 12–15 years is 11.74% [11]. In Germany, the reported rate of RDT is 59.8%, which is higher than any other reports [12]. This high prevalence is possibly attributed to the inclusion criteria of patients who are seeking orthodontic treatment in the study [12].

For reference search strategy, the objective was to determine “What is the prevalence of retained primary teeth?”. A literature search up to October 2023 was conducted using PubMed and Web of Science databases with the search terms (“Retained primary teeth” OR “Retained deciduous

teeth” OR “Retained baby teeth”) AND “prevalence”, restricted to articles in English. The inclusion criteria were based on the PCC framework: Participants (P) are patients under 25 years old, regardless of gender or race; Concept (C) involves patients assessed for RDT, without systemic diseases; Context (C) includes social surveys, dental assessments, other factors and the association outcome. Excluded were review and systematic review articles, animal studies, articles with patients over 25 years old, and articles not in English. Initially, 168 articles were found. After screening titles and abstracts, 42 duplicates and 57 irrelevant articles were removed. Sixty-nine potentially eligible full articles were considered for full text evaluation. Of these, 59 articles were excluded based on the inclusion and exclusion criteria, consisting of 30 unrelated articles, five articles with the wrong population (over 25 years of age), four review articles, three case reports, four articles involving systemic diseases, eight etiological studies and seven articles where prevalence was excluded. Finally, 10 articles were included in this review (Fig. 1). One table summarizes the prevalence of RDT (Table 1). However, since most studies included are cross-sectional and articles in other languages were excluded, this might lead to bias.

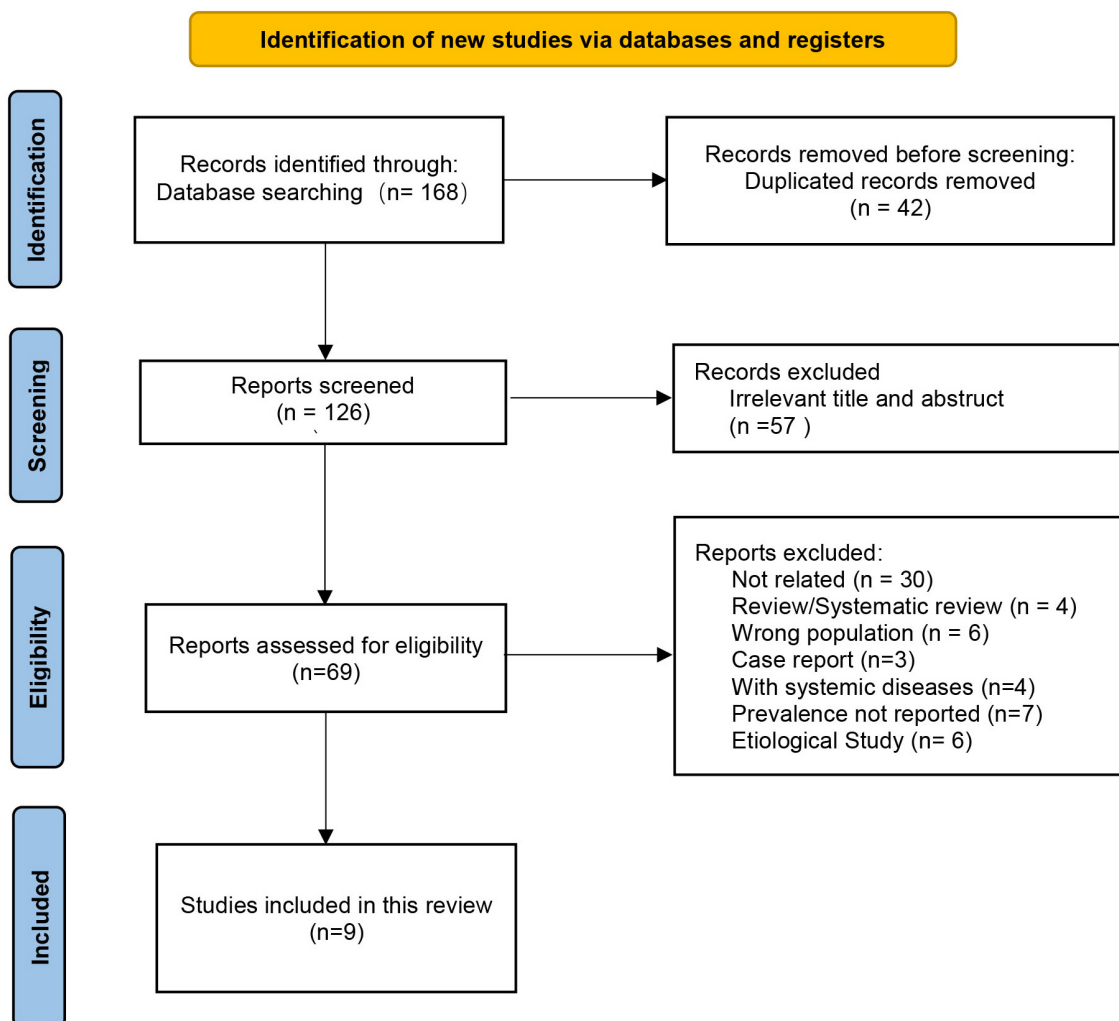


FIGURE 1. Flowchart according to the PRISMA checklist.

**TABLE 1. The position and prevalence of RDT.**

Author (yr)	Type of study	Country/City	Sample population	Tooth position, RDT rate	Overall RDT rate	Other outcomes
Neelesh G (2023) [8]	Cross-sectional study	Indore, Madhya Pradesh	500 patients between 6 to 20 yrs old	Incisor, 3.0% (15/500) Canine, 3.0% (15/500) Molar, 3.6% (18/500)	9.6%	Agenesis of the permanent successor is the most frequent causes of primary molar retention, followed by ectopic eruption and impaction of the successor teeth.
Marra PM (2021) [10]	Cross-sectional study	Naples, Italy	200 patients between 9 to 14 yrs old with odontomas	Canine (13%); premolar (0.5%); molar (0.5%) for compound odontomas Second Molar (1.5%) for complex odontomas	16.5%	The most affected retained tooth is the lower primary canine, missing the eruptive thrust of the permanent, remains in the arch.
Liu JY (2022) [11]	Cross-sectional Study	Taiyuan, China	11,351 patients between 12 to 15 yrs old	Not reported	11.7%	Socio-economic factors and individual characteristic behaviors are closely related to the RDT of adolescents aged 12–15 years.
Iraqi G (2019) [13]	Retrospective Study	Makkah, Kingdom of Saudi Arabia	500 patients between 6 to 25 yrs old	Primary second molars, 15.2% (76/500) Mandibular second primary molars, 15% Maxillary second primary molars, 0.2% Bilateral primary molars, 0.6%	15.2%	Agenesis of the permanent successor, followed by ectopic eruption and impaction of the successor teeth is the most frequent causes of primary molar retention. Tipping of the adjacent permanent teeth, resorption of the primary molar, primary molar caries and pathology, and fillings required in the primary molar are the most common problems associated with retained primary teeth. Dental caries, such as untreated caries, dental fillings, and endodontic treatment is the most common pathological conditions associated with RDT
Henklein SD (2023) [14]	Cross-sectional Study	Germany	102 patients between 8 to 17 yrs old	Incisors, 100% (1/1) Canines, 44.9% (75/167) Molars, 75.4% (306/406)	59.8%	Dental anomalies occurred more commonly in the maxilla, while the most prevalent anomaly was hypoplasia, then retained primary tooth and hypodontia.
Olatosi OO (2022) [15]	Cross-sectional study	Lagos, Nigeria	6175 patients between 6 to 10 yrs old	Maxillary only, 2.4% (148/6175) Mandible only, 2.0% (121/6175) Both arches, 1.3% (77/6175)	5.6%	Dental anomalies occurred more commonly in the maxilla, while the most prevalent anomaly was hypoplasia, then retained primary tooth and hypodontia.
Bandaru BK (2019) [16]	Cross-sectional study	Andhra Pradesh, India	5000 children between 3 to 15 yrs old	Maxilla, 0.02% (1/5000) Mandible, 0.02% (1/5000)	0.0%	Tongue-tie, fluorosis and high frenal attachment were the most common developmental anomalies.
Yang F (2019) [17]	Retrospect study	Wuhan, China	474 online consultations of paediatric dentistry	Not reported	26.6%	Emphasizing the necessity for efficient dental emergency triage to conserve medical resources and reduce the risk of broader population exposure under COVID-19 restrictions
Al-Abdallah M (2015) [18]	Cross-sectional study	Amman, Jordan	3315 patients Mean age: 17.3 ± 4.7	Maxilla, 0.3% (10/3315) Mandible, 1.3% (42/3315)	1.6%	Maxillary hypodontia is strongly linked to microdontia of the maxillary lateral incisors, while mandibular hypodontia is associated with retained deciduous molars, infra-occlusion of deciduous molars, and impaction.

RDT: Retained deciduous teeth.

Gender and race can also affect the prevalence of RDT. Retention rates are generally higher in females than in males [13]. Additionally, differences in RDT rates have been observed among various races [2].

Certain primary teeth are more likely to be retained than others. Among these, the mandibular central incisor is the most frequently retained. Furthermore, when the permanent successor is missing, the corresponding primary tooth is more likely to be retained. Aktan *et al.* [19] found that the mandibular second premolars are the most commonly missing teeth due to agenesis (Male = 20.09%, Female = 38.26%), followed by the maxillary canines (Male = 8.12%, Female = 15.21%), maxillary second premolars (Male = 3.25%, Female = 7.53%), and the mandibular incisors (Male = 1.18%, Female = 0.59%). These findings are consistent with the results from Iraqi *et al.* [13].

### 3. Etiology of RDT

There are several etiologies of RDT (Fig. 2).

The absence or ectopic eruption of permanent teeth is the most common cause of RDT in Western countries. Issues such as delayed eruption, impaction, and abnormal positioning of permanent teeth can also contribute to RDT [14]. As mentioned earlier, the congenital absence of the permanent successor is the primary reason for RDT [2, 14].

Dental diseases can lead to RDT, including caries, apical periodontitis, dentigerous cysts, impacted primary tooth, and ankylosed tooth [20–22]. Yawaka *et al.* [21] described a case where a patient had two teeth of RDT due to apical periodonti-

tis. The right mandibular first primary molar (tooth #84, by the FDI tooth system) is retained because the permanent successor (tooth #44) ectopically erupts, while the left mandibular second primary molar (tooth #75) is retained because the permanent successor is submerged due to a cyst that harbors it [21]. Manekar *et al.* [20] detailed five cases where untreated pulpitis in deciduous teeth led to apical periodontitis and apical cysts, contributing to RDT development. Teeth ankylosis and infraocclusion are additional causes of RDT [22].

Genetic disorders are also implicated in RDT. Wolf-Hirschhorn syndrome (WHS) is a congenital disease caused by microdeletion of the short arm of chromosome 4 (del 4p16.3), which affects the *MSX1* gene [23]. WHS can lead to various oral diseases including periodontitis, tooth hypoplasia and delayed tooth eruption. Dental hypoplasia is a common factor in RDT development [24].

Signal transducer and activator of transcription 3 hyper-IgE syndrome (STAT3-HIES), a rare primary immunodeficiency, is linked to several oral conditions including RDT, gingivitis and aphthous ulcers [25]. Meixner *et al.* [25] found that 83% of patients with STAT3-HIES experienced prolonged retention of primary teeth, resulting in delayed eruption of permanent teeth. Furthermore, cleidocranial dysplasia (CCD), a condition with an estimated prevalence of one per million, is also a known cause of RDT.

Down Syndrome, characterized by midfacial hypoplasia, can contribute to the development of several dental conditions [26]. Among individuals with Down Syndrome, there is a 31% likelihood of experiencing RDT [27].

Mucopolysaccharidosis II (MPS II), also known as Hunter

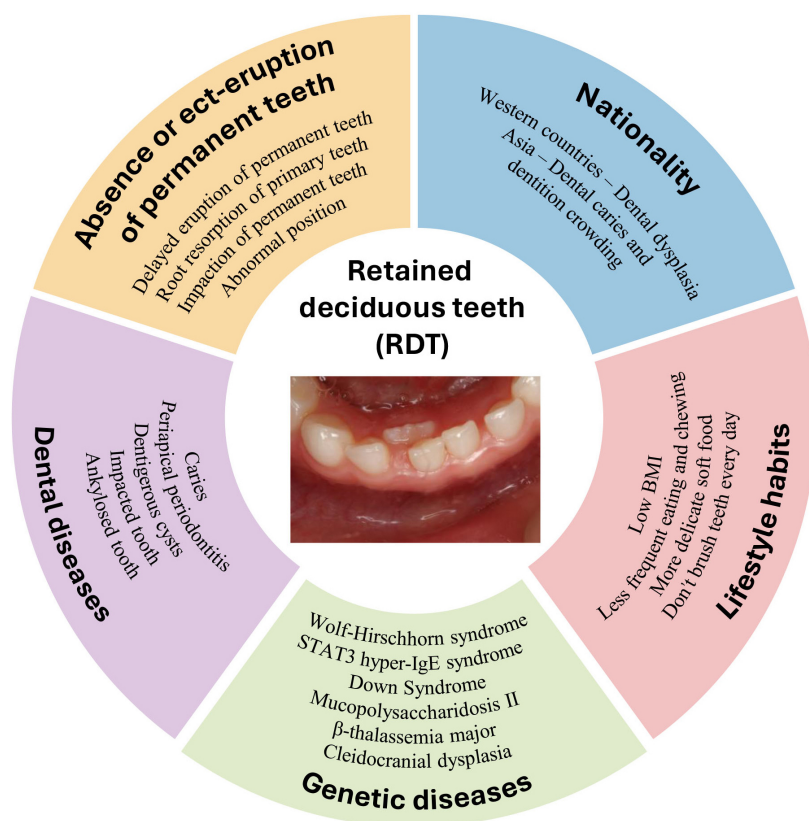


FIGURE 2. The etiology of RDT. STAT: Signal Transducer and Activator of Transcription; BMI: Body Mass Index.



syndrome, is a rare metabolic disorder caused by a deficiency of the enzyme iduronate sulfatase. This deficiency leads to the accumulation of dermatan and heparan sulfates in various tissues [28]. Consequently, this can result in abnormal development of the mandible and teeth, which may contribute to the occurrence of retained deciduous teeth [29].

$\beta$ -thalassemia major (BTM) is a severe congenital hemolytic disease that affects facial development in addition to causing hemolytic anemia. Sheikha *et al.* [30] found that individuals with BTM had a significantly higher incidence of retained primary teeth compared to controls, with up to 18.4% of individuals affected.

Cleidocranial dysplasia, a rare congenital anomaly often observed in Asia, is inherited in an autosomal dominant manner. This condition can affect the development of facial bones and disrupt normal eruption patterns, leading to the presence of supernumerary teeth. These factors can contribute to the occurrence of RDT [31].

Various lifestyle factors can influence the incidence of RDT. Liu *et al.* [11] observed that individuals with a higher body mass index (BMI) are less likely to experience RDT. They noted that increased frequency of eating and chewing might promote tooth loss in infants and stimulate the eruption of permanent teeth [11]. Additionally, children and teenagers today often consume softer, less abrasive foods, which might decrease the effect of chewing on jaw development and contribute to the occurrence of RDT [11]. However, regular tooth brushing can help prevent primary teeth caries and indirectly reduce the prevalence of RDT [11].

Geographic location also plays a role in the primary causes of RDT. In China, the main causes are dental caries, followed by periodontal issues [11]. When comparing tooth morphology and maxillofacial growth, Chinese children typically have larger deciduous teeth than other populations, including Americans, Africans and Japanese [32]. Moreover, Chinese young adults often have shorter mandibles and smaller midfaces than Caucasians, which suggests that their dental development, influenced by genetic factors, tends to be more concentrated and crowded, thereby increasing their risk for RDT [33]. Conversely, in Europe and America, the most common cause of RDT is the absence of the tooth germ of permanent teeth, particularly the mandibular second premolars [2]. Dietary habits also differ regionally. Chinese parents usually provide their children with more refined and soft foods, which may not effectively stimulate the loss of deciduous teeth. In contrast, European and American diets, which emphasize independent eating and include higher protein and more meat, tend to accelerate the eruption of permanent teeth [34].

#### 4. The adverse consequence of RDT

Untreated RDT can lead to oral complications, impacting both physical and mental health. Therefore, treatments may be necessary based on individual circumstances. Without proper management, RDT increases the risk of dental caries, periodontal disease, malocclusion and other related issues [35].

The issue of tooth alignment and malocclusion should also be addressed. Chantic *et al.* [36] reported that the prevalence of retained primary teeth is high, reaching 58%, in children

with crowded malocclusions. Zou *et al.* [37] noted that prolonged preservation of RDT due to unusual root resorption can alter the eruption path of the permanent tooth. This is often observed in the front mandibular region, where the central incisors erupt toward the tongue, unlike their predecessors [37]. If the maxillary central incisor is retained, it can cause the adult incisor to erupt abnormally toward the palate, resulting in a simple anterior crossbite [37]. Malocclusion can adversely affect speech, chewing and overall oral health. Anand *et al.* [38] discovered that 28.5% of patients with malocclusion have retained deciduous teeth.

RDT can also influence the growth of permanent successors. For example, if a submerged primary tooth is preserved in the hope that it will naturally exfoliate, it may block the space needed for the erupting permanent successor, leading to failure or ectopic eruption of the permanent tooth [39]. Additionally, a submerged primary tooth increases the risk of permanent tooth impaction [40].

Primary teeth are more susceptible to caries due to their lower mineralization, thinner enamel and dentin compared to permanent teeth. If a primary tooth does not exfoliate on time, RDT can increase the caries risk for this tooth. If left untreated, dental caries in RDT can cause pain, infection, and hinder the eruption and growth of permanent successors [41].

RDT also raises the risk of dental caries and periodontal diseases, with the incidence rate of the latter being about 24.96% [14]. Andrea *et al.* [42] analyzed risk factors in the development of childhood caries. They identified poor oral hygiene and dietary habits that contribute to the accumulation of dental plaque as important factors that promote these conditions [42]. Due to its abnormal position, RDT can easily accumulate dental plaque, thereby increasing the susceptibility to caries and periodontal disease.

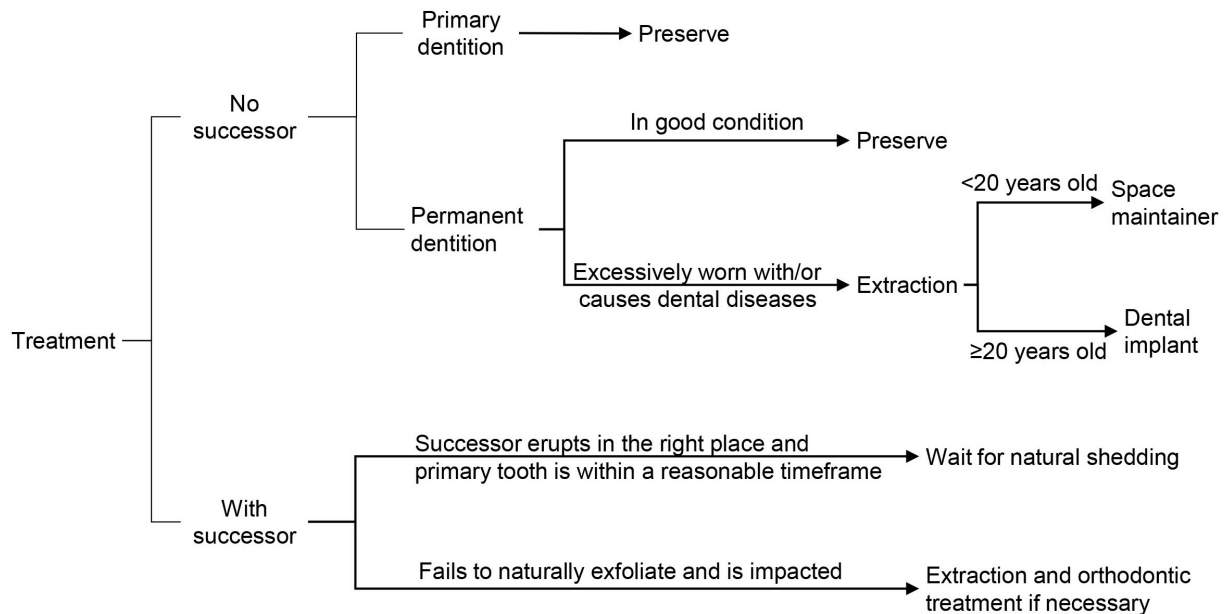
RDT can make patients feel self-conscious about their appearance. Depending on the location of the retained teeth in the mouth, these teeth may be visible when smiling or speaking, which can lead to aesthetic concerns [43, 44].

#### 5. The treatment and prevention of RDT

It is important to provide appropriate treatment for RDT, which can vary depending on each individual's situation (Fig. 3).

If there are no permanent successors to replace the primary teeth and the RDT are in good condition, preservation is necessary for as long as possible, especially during the adolescent years. To restore the aesthetics and function of RDT, particularly in the smile zone, ceramic veneers are recommended when there is no successor and the RDT has a healthy root and crown ratio [43, 44]. Bin-Shuwaish *et al.* [43] suggest that this approach can effectively address minor tooth malalignment and malocclusion, resulting in improved aesthetics and chewing function. Additionally, the veneer remains in good condition without any symptoms in a four-year follow-up [43]. Similarly, Parise Gré *et al.* [44] utilized ceramic crowns made of lithium disilicate glass-ceramic material to achieve a natural and beautiful smile for their patient. The restoration of RDT not only improves tooth appearance but may also correct the malocclusion and promote proper bite [7].

When RDT are excessively worn and cause conditions such



**FIGURE 3. RDT treatment decision tree.**

as gingival recession, dental implants can be used to replace them when patients reach adulthood [45]. Jae *et al.* [46] emphasize the importance of a comprehensive treatment plan following a guided implant workflow. The ideal implant location is determined by a diagnostic wax-up as it is important to visualize the desired contours of the final restoration and its relation to the planned implant position [47]. Unlike dental bridges, a dental implant does not require adjacent teeth preparation, and it also maintains periodontal health and the alveolar crest [45].

If permanent teeth successors are expected to erupt in the correct place and within a reasonable timeframe, a “wait and see” approach is the best treatment choice [40]. This approach is suitable if the patient is willing to cooperate and understand the advantages and disadvantages of this treatment [40]. Moreover, they should be able to attend regular follow-up appointments [40].

In cases where teeth fail to naturally exfoliate or when the development of permanent teeth is ectopically erupted, it is recommended to promptly extract RDT and, if necessary, consider orthodontic intervention. If RDT can be extracted timely, the related complications can be reduced. For instance, in patients with STAT3-HIES, if RDT are identified and extracted around the natural shedding age, the permanent tooth can erupt normally without being affected by the RDT [25]. This may reduce the need for orthodontic treatment [25], which not only saves time for orthodontic procedures but also reduces treatment costs. However, if RDT has not been extracted in time, a complex orthodontic treatment would be required to ensure the proper eruption of permanent teeth [7]. The ultimate goal of orthodontic treatment is to achieve a well-interdigitated class II molar relationship, along with an ideal overjet and overbite, and a normal facial appearance [47].

To prevent the occurrence of RDT in the general population, it is advisable to maintain good lifestyle habits. Children should consume more solid hard foods to stimulate the natural

shedding of primary teeth and the growth of the jaw, which provides more space for the eruption of permanent teeth [38]. Adopting a healthy diet low in sugar and rich in vegetable fibers can support good oral health, reducing the risk of dental caries and related RDT [48]. Children are advised to reduce their intake of starch and sucrose. The use of xylitol, sorbitol and erythritol can interfere with the growth and acid production of cariogenic bacteria, such as *Streptococcus mutans*, and therefore contribute to caries control [49]. Meanwhile, in a broader scope, maintaining good oral health, having pit and fissure sealing, and routinely conducting fluoride varnish are beneficial lifestyle habits.

## 6. Conclusion

In recent years, there has been a noticeable shift in children’s dietary preferences, leading to an increased consumption of softer food. Consequently, the prevalence of RDT has risen. While the abnormal development of permanent successors is the primary cause of deciduous tooth retention in Europe and the United States, factors such as small craniofacial bones and excessive consumption of refined food contribute to this issue in China. RDT can potentially contribute to several oral diseases, and treatment approaches may vary depending on each case. More importantly, early detection, diagnosis, and treatment are crucial in disease control and reducing complications. This review has comprehensively summarized the epidemiology and etiology of RDT and provides suggestions for its treatment and prevention, in order to raise awareness of this disease among dentists and the public. The limitations of this review are that it is mainly based on cross-sectional studies and retrospective studies, instead of prospective studies. To improve the overall welfare of children with RDT and to better understand RDT, future studies should focus on the etiology and large-scale epidemiology of this condition.

## ABBREVIATIONS

RDT, retained deciduous/primary teeth; WHS, Wolf-Hirschhorn syndrome; STAT3-HIES, signal transducer and activator of transcription 3 hyper-IgE syndrome; CCD, cleidocranial dysplasia; MPS II, Mucopolysaccharidosis II; BTM,  $\beta$ -thalassemia major; BMI, body mass index.

## AVAILABILITY OF DATA AND MATERIALS

Not applicable.

## AUTHOR CONTRIBUTIONS

RJ—contributes to the conception or design of the work, drafts the work, gives final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. RH—contributes to the conception or design of the work, revises the work, obtains funding, gives final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors read and approved the final manuscript.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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