Critical Review
Pediatric Dentistry

Does the premature loss of primary anterior teeth cause morphological, functional and psychosocial consequences?

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Abstract: Premature loss of primary anterior teeth in deciduous arches is a controversial topic in the literature, especially due to the lack of robust scientific evidence regarding the types and magnitudes of the consequences involved. Morphological, functional, and psychosocial problems may arise from untreated premature loss of primary incisors and canines. The morphological problems include impaction and eruption disturbances of permanent successors; inclination and/or extrusion of adjacent and antagonist teeth, respectively; midline deviation; and crowding. Functional complications, such as speech disorders, aesthetic problems, and development of non-nutritive habits may occur, resulting in psychosocial implications, including a decrease in self-esteem, and even being targeted for bullying. The current critical review aimed to present and discuss the evidence available in the literature about the etiology, characteristics, implications and interventions resulting from the premature loss of primary anterior teeth. It is of utmost importance that future studies be developed to support the clinical decisions made by dental professionals on this topic.

Keywords: Incisor; Cuspid; Tooth, Deciduous; Tooth Avulsion; Tooth Extraction.

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Introduction

Primary dentition plays critical morphological, functional and psychosocial roles in child development, by providing proper conditions for skeletal and muscular growth, establishment of occlusion, mastication, phonation and aesthetics[1]. Furthermore, maintaining deciduous arch integrity exerts a strong influence on developing permanent dentition, conserving dental arch length, and retaining the space needed for successor teeth to erupt.[1]

The time during which primary tooth loss endures is a major factor to be considered. Although it has been reported that tooth loss is considered premature when it occurs at least one year before the normal exfoliation period,[2] the approach of estimating tooth eruption according to dental age is considered a more reliable method than using the child's chronological age.[3] According to Nolla's radiographic assessment of dental age, primary

tooth loss is considered premature when the successor permanent tooth has still not developed beyond Nolla's stage six, in which coronary formation is completed and eruptive movements are initiated.[3]

The premature loss of primary teeth is considered an oral health problem, owing to associated aspects of functional and psychological damage[4]. The most common etiologies are related to trauma, advanced dental caries, neonatal tooth extraction and premature root resorption.[4,5,6]

Sequelae resulting from premature loss of anterior teeth may affect a patient's speech evolution;[7,8,9,10] development and eruption of permanent successor teeth;[11] establishment of malocclusion in permanent dentition;[12] arch integrity;[13,14,15] and onset of non-nutritive habits.[16,17] When present, these consequences may require intervention with space maintainers.[18] Nevertheless, there are two divergent viewpoints regarding space maintenance in the anterior area, whereas the former supports the use of oral appliances,[19,20] the latter disagrees with this recommendation[21,22]. Those who support the use of space maintainers believe that premature loss can cause space loss in dental arches, and that this can be prevented with space maintenance.[19,20] On the other hand, those who oppose the use of space maintainers argue that the spaces resulting from premature tooth loss may be unaffected, and that a space maintainer may therefore by dispensed with.[21,22] In addition, from the perspective of these authors, patients with negative arch discrepancies might require orthodontic treatment, regardless of the arch perimeter impairment due to the premature loss.[21,22] Lastly, these authors also discuss that many lost spaces are recovered when the permanent successor erupts.[21,22]

Despite our previous knowledge of the topic, the authors still find that issues, such as the amount of space change in dental arches, and the dental and skeletal consequences that follow the premature loss of anterior teeth, are not sufficiently understood. Additionally, the available data on the psychosocial effects of such loss on children's and parents' quality of life, aesthetics,[23] and phonation are also unsatisfactory.[24,25] In this respect, the purpose of this critical review was to present and discuss the evidence available in the literature concerning etiology, diagnosis, implications and interventions following the premature loss of primary anterior teeth.

Methodology

This revision was based on a PubMed/Medline search using MeSH terms, synonyms and key words related to primary anterior teeth and tooth loss, chosen specifically to avoid any restriction, and to maximize the search field in this research phase. No restriction on language or publication data was placed on the search strategy. Studies with different designs were included, such as observational studies, case series, literature reviews, and systematic reviews, among others. Articles published up to April 2020 were considered for this critical review. A manual search was also performed on the reference lists of the selected articles. The studies were selected based on evaluation of the titles and abstracts of all the studies identified in the electronic database.

Full articles were read and the data were extracted to perform the critical review. The information extracted from the selected studies was defined in order to gather and synthesize the key information. The following data were extracted from the studies: study subjects, objectives, methodology, results and main conclusions of each study. When the data did not appear to be sufficient or was inconclusive, the critical analysis was based on expert and/or consensus opinion by experienced researchers.

The confidence in selecting the results of a certain study depends on the study design and the level of evidence; to this end, the present review comprised a broad analysis of the literature, to encourage discussions about study methods and results, as well as reflections on future studies. The ultimate goal was to gain a sufficient body of knowledge on the investigated topic.

Results and discussion

Etiology of premature loss of primary teeth

The etiology of premature loss of posterior teeth is usually associated with advanced dental caries[26], whereas premature loss of anterior teeth is related to

dental trauma, dental caries, neonatal tooth extraction and premature root resorption[5,6].

Regarding dental trauma, a previous meta-analysis showed a 22.7% worldwide prevalence of traumatic dental injuries in primary teeth[27]. Premature loss of primary anterior teeth due to avulsion ranges between 5.8% and 19.4%,[23] and frequently occurs in children aged 2–4 years. In addition, premature loss of primary anterior teeth can result from an extraction after injury based on poor prognosis, late complications, early exfoliation following accelerated root reabsorption, intrusion, root fracture, and several different types of luxation injuries.[23,28]

Regarding dental caries, despite the decline in its incidence improved by preventive programs, a significant number of children still develop this disease[29]. A previous systematic review revealed that the prevalence of dental caries among 5-year-old children ranged from 22.9%[30] to 90%.[31] It is worth mentioning that the wide-ranging discrepancy in dental caries prevalence globally reflects the diversity of the many countries of origin of the studies included in this systematic review,[32] and that dental caries in preschool children still remains prevalent in most nations worldwide.[32] Caries may cause premature tooth loss when lesion progression is advanced, and endodontic tooth treatment is not recommended due to accelerated root reabsorption or when rubber dam isolation cannot be performed, then the tooth must be extracted.[29,32,33]

Other etiological factors related to premature loss of primary anterior teeth are natal and neonatal teeth, described as those already present in the baby's oral cavity at the moment of the birth, and those that appear in the oral cavity during the first month of life, respectively.[15] The proportion of natal or neonatal teeth ranges from close to 0 to 1:10 cases.[34] Premature extraction of these teeth is normally indicated, owing to the relevant clinical mobility due to the absence of root formation and inadequate tooth implantation.[35] Such faulty implantation could result in tooth displacement, and subsequent swallowing or aspiration by the baby; this concern fully warrants tooth extraction.[36] Additionally, in some cases, primary tooth extraction might be necessary, because of a child's inability to accept long restorative or endodontic dental treatments, or else the parents' refusal to approve complex treatments, including lengthy endodontic procedures.[23]

It is also worth mentioning that premature loss of primary anterior teeth might result from root resorption due to tooth size discrepancies between primary and permanent teeth, particularly in crowded dental arches.[5] The most frequently affected teeth include primary lower canines and upper lateral incisors, followed by upper canines, lower lateral incisors, and second molars.[5]

Premature loss of primary anterior teeth

Incisors

Premature loss of primary anterior incisors is usually caused by traumatic dental injuries.[23] Loss of a primary incisor is more commonly observed in the maxilla than in the mandible.[38] On one hand, the premature loss of maxillary incisors has minimal impact on mastication or other functions, and the space loss is usually insignificant, unless the teeth are lost at a very young age, or in case of associated crowding, excessive overjet or deep overbite malocclusions.[38] On the other hand, the main consequences reported are incisive function impairment, speech problems, including distortion and articulation errors during the pronunciation of consonants,[8] and aesthetic issues.[23]

Regarding the number of incisors lost or extracted, it has been suggested that, if just one central incisor is lost at an early age (Figure 1), no major dental arch changes are expected, except for a possible slight midline deviation[39]. However, when both central incisors are lost (Figure 2), it has been reported that there is no significant impact on arch perimeter, but that there is a possibility that deleterious habits such as tongue thrusting[39] may be established. When central and lateral incisors are lost prematurely (Figure 3), the consequences of establishing deleterious oral habits may be greater, in addition to other outcomes, like extrusion of lower incisors to compensate the lack of contact with opposing teeth.[39]

Figure 1. Patient M.A.F.S., male, 5 years old, unilateral premature loss of primary central incisor (61). Intraoral frontal photograph 3 years after premature tooth loss. (Image by Patricia Nadelman PhD student - CVMT/FO-UFRJ®)

Figure 2. Patient I.G.L., female, 5 years old, bilateral premature loss of primary central incisors (51 and 61). Intraoral frontal photograph one year after the premature loss. (Image by Patricia Nadelman PhD student - CVMT/FO-UFRJ®).

Figure 3. Patient M.C.C., female, 4 years old, premature loss of primary central incisors and lateral incisor (51,61 and 62). Intraoral frontal photograph 6 months after the loss. (Image by Patricia Nadelman PhD student - CVMT/FO-UFRJ®).

Canines

Premature loss of primary canines is usually caused by ectopic eruption of permanent lateral incisors, accelerating the resorption of one or both primary canine roots.[38] Notably, this phenomenon can occur in both mandibular and maxillary arches.[38] Trauma is another reason for premature loss of canines, but with reduced prevalence.[23]

Figure 4. Patient M.F.F., male, 4 years old, unilateral premature loss of primary canine (53). Intraoral frontal photograph 15 days after the loss. (Image by Fernanda Vieira, Master's student - CVMT/FO-UFRJ®).

Concerning the number of canines lost or extracted, unilateral cases (Figure 4) usually present permanent incisor shift toward the affected side, and a resultant midline deviation.[38] It has been suggested that if the loss is bilateral, instability is reduced.[38] When loss occurs in the mandibular arch, it might result in a lingual inclination of the permanent lower incisors, and consequent arch perimeter reduction.[40]

To date, there has been no consistent information on the premature loss of primary anterior teeth in regard to either the types (incisors or canines) or the quantity of primary anterior tooth loss.[38] There are a few studies in the literature that do not provide an adequate quality of evidence, attributed especially to methodological flaws.[7,8,9,14,15,24,25] It is worth mentioning that the majority of studies are reviews, but they should ideally be observational or interventional clinical studies.[18,23,38] To the best of our knowledge, this is the first critical review comprising all the aspects of premature loss of primary anterior teeth, including the etiology, diagnosis, consequences and interventions. The current critical review also presents relevance, insofar as it highlights the need for further studies on this topic.

Consequences of premature loss of anterior teeth

The consequences of premature loss of anterior teeth involve morphological, functional and psychosocial

aspects.[23] Morphological effects include interferences in development and eruption of permanent successors teeth, as well as impairment of arch integrity.[23] Functional impairments comprise alteration of speech evolution, and establishment of non-nutritive habits.[23] Lastly, psychosocial damages may influence a child's aesthetic perceptions and quality of life.[23]

Morphological consequences

Effects of premature loss on development and eruption of successor teeth.

The premature loss of primary anterior teeth may cause damage to permanent successors, because of its strong relation with arch perimeter reduction, leading to impaction and eruption disturbances (delay or anticipation).[4,41,42,43]

In addition, if premature loss is caused by trauma, it can contribute to the development of other sequelae in permanent teeth, including dental hypoplasia and discoloration, crown or root dilacerations, and sequestration of permanent successor tooth germ.[23] The prevalence of impairment to permanent successor development after avulsion of primary teeth has been reported to range between 30% and 85%.[23] The younger the child at the time of injury, the greater the frequency and severity of the damage observed in permanent successors.[44]

Regarding permanent successor eruption, premature loss of primary anterior teeth may accelerate or delay successor tooth eruption, according to Nolla's dental age assessment.[3] If the loss occurs prior to the successor's reaching Nolla's stage 6 (when the crown is entirely formed), it may result in bone or fibrotic tissue formation on top of the tooth germ, in which case additional resistance to eruption is created, ultimately impacting or delaying the eruption of successor teeth.[3,39] However, if the loss occurs after the successor has reached Nolla's stage 6 – in other words between Nolla's stage 7 and 8 – its eruption can be accelerated, since eruption movements had already been initiated before that stage.[3] It is important to highlight that this acceleration may also be related to the amount of bone loss in cases of periapical lesions. In these situations, there is often an accelerated eruption of the successor, even without the permanent tooth's having reached Nolla's stage 6.[45]

A final consideration is that the premature loss of primary incisors may also be associated with the malposition of their permanent successors.[42] This could result from a lack of eruption guidance for permanent teeth, which may lead to ectopic eruption and resultant malocclusion[42].

Problems related to arch integrity

If deciduous arch integrity is compromised, it can reveal problems regarding permanent tooth alignment due to arch perimeter reduction.[4,5] There is a further possibility of antagonist tooth extrusion, adjacent tooth migration and inclination, permanent successor tooth impaction, early or late eruptions, midline deviation, and discrepancy between the space available in the dental arch and the space needed for adequate accommodation of successor teeth.[4,5]

According to McDonald and Avery,[5] premature loss of upper and/or lower primary incisors may lead to anterior space loss, if it occurs prior to the eruption of the primary canines. In addition, certain other factors might also influence space loss, including Baume's deciduous dental arch types, and the presence of non-nutritive habits. There are cases in which primary anterior teeth are in contact with one another before the tooth loss (*i.e.*, Baume type II arch), or in which there is arch-length discrepancy in the anterior region. These represent potential factors for space loss because space adjustments may occur between the teeth after loss of one of the incisors.[5]

Despite this information, most of the existing studies in the literature, presented in a previous systematic review, are limited to covering the issue of maintaining space for premature loss of posterior teeth.[46] Hence, there remain gaps in our knowledge of the spatial consequences of early loss of anterior teeth. Only a few studies were found in the literature evaluating arch perimeter changes in the deciduous arch itself,[13,14,15] and how these changes affect permanent tooth alignment[12,47] after premature loss or extraction of primary incisors and canines.

In one investigation, Clintch and Healy[13] reported no closure of anterior space after the premature extraction of incisors and canines. Conversely, Kohn[41] claimed that the space in the incisor region must be maintained if premature loss occurs prior to the age

of four years, since the crowns of permanent incisor are too high up in the maxilla to successfully maintain the space. Furthermore, Miyamoto, Chung and Yee[12] indicated that the premature loss of one or more primary canines requires more frequent orthodontic treatment to manage permanent dentition.

Lastly, a couple of previous studies[12,13,14,15,47] presented some limitations, such as small sample size and absence of a control group.

Functional consequences

Speech impairment

Regarding phonation, it is known that teeth play an important role during the production of certain speech sounds.[48] Consequently, tooth loss may impair the pronunciation of certain consonants (*e.g.*, 'v', 'f', 'th', 'z', and 's'), since their correct production requires forcing the air stream through an opening in the oral cavity small enough to produce frictional noises.[48] Moreover, anterior maxillary teeth are considered one of the structures responsible for speech development and the articulation of certain sounds.[23] It is also known that anterior teeth appear to be particularly important for the correct production of certain phonemes, mainly 's' and 'z' sounds;[8,24] therefore, premature loss of these teeth may lead to speech problems. Riekman and ElBadrawy evaluated the speech of 14 children, with an average age of 22.7 months, who had their maxillary primary incisors extracted, as a result of nursing bottle caries (early childhood caries),[24] and reported that impairment of young children's speech could occur if they experienced the premature loss or extraction of their four maxillary primary incisors. It is also important to consider that the sequelae of premature tooth loss on speech might vary not only according to chronological criteria, but also to a child's individual speech pattern, since the child may have acquired the ability to pronounce phonemes properly at early stages of development. Nevertheless, some authors suggest that phonation problems in children younger than 5 years old may be considered normal, since the acquisition of all phonemes should be complete by the literacy phase.[35] Therefore, the diagnosis of speech disorders can only be confirmed after 5 years of age, at which time persistent phonation problems should be evaluated and treated as soon as possible.[35]

Additionally, Kalia et al.[49] evaluated speech changes before and after prosthetic rehabilitation with fixed functional space maintainers in children with missing maxillary anterior teeth. Their study observed significant distortions and articulation errors of 'v', 'd', 'dh', 't', 'th', 's', and 'sh' consonants. They also described an improvement in the articulation of these sounds after fixed appliances were inserted in children aged 3 to 6 years, with at least two missing maxillary anterior teeth.

The only systematic review and meta-analysis[10] published on this topic in the literature evaluated the consequences of premature loss of primary anterior teeth on children's speech and arch integrity, compared to children without premature losses. This meta-analysis showed that the premature loss of primary anterior teeth might cause speech distortion. Despite this information, the few studies published in the literature that investigated the consequences of premature loss/extraction of primary anterior teeth have methodological limitations of and low-level evidence-based quality, and are based on outdated literature.

Development of non-nutritive habits

Another consequence of premature primary anterior tooth loss is the development of non-nutritive habits in children who did not present these habits before the loss, and an increase in the frequency of those who did, particularly with a previous history of pacifier use, digital sucking, and tongue thrusting.[4,23] Normally, the establishment of non-nutritive habits is overlooked in relating the sequela of early tooth loss. More commonly, it has been reported to cause atypical swallowing, with tongue thrusting occurring in the unnatural space. Long-term alterations can cause impairment of respiratory ability and delayed nasal breathing, and even induce mouth-breathing development.[50,51]

Tongue thrusting[1,4,16,17] is one of the main non-nutritive habits established as a consequence of tooth loss, and an extremely important issue that must be managed.[51] Additionally, the presence of non-nutritive habits may influence morphological changes, such

as dental arch space loss.[5] The magnitude of the changes resulting from oral habits depends on three factors: frequency, intensity and duration of the habit, described as Graber's Triad.[4]

Psychosocial consequences

There are currently gaps in the literature concerning the impact of early loss of primary anterior teeth on children's quality of life.[23] Several instruments have been developed to assess the oral health-related quality of life, according to each age group,[52] by means of direct and proxy sources of information. Direct instruments comprise patient-reported data, such as the Scale of Oral Health Outcomes for 5-year-old children (SOHO-5).[53] However, it should be borne in mind that the children's responses may be limited, considering that children younger than 5 years old might not be aware of the tooth loss,[54] and are too young to understand how lacking a tooth really affects their oral aesthetics or quality of life.[23]

Since the young age of patients may be a limiting factor for the application of direct questionnaires, authors should develop studies using proxy-reported measures to assess a young patient's quality of life through reports by parents.[55] The approach using proxies, such as the Early Childhood Oral Health Impact Scale (ECOHIS),[56] can provide relevant information on how parents conceive their child's perception of premature loss on quality of life.[56]

Since young children are practical and simplistic in dealing with issues related to their oral health, some concerns are commonly restricted to the parents' perceptions.[23] They imagine that the premature loss of primary anterior teeth may affect the child's appearance, by making the child unattractive.[57,58,59] This could be a limitation of the proxy-reported questionnaires, which would probably express the guardians' understanding of tooth loss rather than the child's perception. The abovementioned constraints may explain the few studies conducted in this age group.[7,8,9] According to Moss and Maccardo,[54] children are not aware of any damage to a primary tooth prior to the age of five or six years old, and would not be aware of early loss of an incisor or a canine if this injury occurred before four years of age.

In stark contrast, a study revealed that preschool-aged children point out characteristics of other kids based on their own appearance.[60] Kapur et al.[61] suggested that younger children, even those younger than three years of age, are aware of their appearance and ask their parents to look for dentists to resolve aesthetic issues resulting from missing teeth. The authors add that parents and caregivers are most likely to be affected by their children's premature tooth loss[23], but there are few data in the literature supporting this finding.

Interventions

There are two conflicting scientific thoughts concerning the management and treatment of premature anterior tooth loss or extractions. The main issue is whether or not to intervene in cases of premature loss or extraction of primary incisors and canines. Those who oppose using space maintainers claim that the space resulting from early loss may or may not diminish over time.[17] In cases where spaces do no diminish, intervention with a space maintainer can be dispensed with, whereas cases of previous negative arch discrepancy require that patients seek orthodontic treatment to recover the space, regardless of arch perimeter reduction due to premature loss.[21,22] Moreover, researchers believe that anterior losses do not compromise the arch perimeter as much as posterior losses do.[18]

Conversely, those who favor the use of space maintainers believe that a prematurely lost space is usually permanently lost, and this may cause deleterious effects on permanent dentition, owing to a reduction in the arch perimeter.[19] In addition, if a primary anterior tooth is lost at a very early age, bone may form from the dental germ, and cause late eruption of the permanent tooth, ultimately also resulting in an arch perimeter reduction.[5]

Considering the number of primary anterior teeth lost or extracted, it has been suggested that if just one or two central incisors are lost early, the use of a space maintainer is not strictly necessary. However, when both central and lateral incisors are lost prematurely, the use of a space maintainer should be considered, because multiple losses could favor the development of deleterious oral habits, in

addition to dental extrusion from lack of contact with the opposing teeth[39] and speech impairment. Regarding the premature loss of primary canines, an appropriate appliance for space maintenance should be considered, since this loss represents a major problem caused by the adjacent tooth's shifting, and potential midline deviation.[39]

Among the space maintainers for the anterior region, a fixed aesthetic space maintainer is preferred[38]. This appliance is a variation of the fixed bilateral space maintainer, and is indicated specifically for replacing missing maxillary incisors. Although this appliance is used primarily to resolve aesthetic issues, it can also help with a child's mastication and phonation.[38] Regarding removable aesthetic appliances, they are less widely used because children who lose anterior teeth early are usually very young, and too immature to use removable appliances, owing to the risk of deglutition, and the possibility that the child will not comply with its wear and care instructions[5]. Moreover, appliances that are indicated to best address mandibular canine losses are normally lower-lingual holding arches. These space maintainers are designed to include soldered hooks to resist or inhibit the distal shifting of incisors.[38]

Additionally, there is a classic recommendation published in the literature[62] regarding the need for maintaining space in the anterior region. If primary maxillary and mandibular incisors are lost after the eruption of canines, space maintenance is not necessary because the lower arch is 'coupled to' or 'inside' the upper arch, and the space would likely reopen when the permanent teeth erupts.[62] On the other hand, if the loss of a primary incisor occurs prior to eruption of the canines, space maintenance is needed because the primary lateral incisors could shift distally, resulting in space loss and occupation of the space of the primary canines. Finally, if a lower or upper primary canine is lost, the space must also be maintained to prevent midline deviation.

As a final consideration in this section, it is important to point out that the use of fixed maintainers requires some special care, including biofilm control with adequate oral hygiene and controlled diet, since the retention of bulky food waste in oral devices may increase the risk of caries progression.[36] Hence, a fixed space maintainer is contraindicated in patients with a high risk of caries and deficient biofilm control.[36] Furthermore, a periodic follow-up for professional prophylaxis is recommended.[36]

Conclusion

The absence of robust scientific data on the implications and possible interventions for premature loss of primary incisors and canines has led dental professionals to depend largely on clinical experiences in deciding the clinical course of treatment. However, clinical decisions should be made based on scientific evidence, whenever possible.

Currently, the scientific literature shows that the etiology of the premature loss of primary anterior teeth may be associated with extraction resulting from advanced dental caries; trauma related to avulsion or extraction based on poor prognosis, late complications, or early exfoliation following primary tooth accelerated root reabsorption; premature root resorption; and neonatal tooth extraction. Premature tooth loss diagnosis can be performed based on the patient's dental history, and clinical and radiographic examinations.

Data also shows that the implications resulting from premature anterior tooth loss may or may not interfere in the development and eruption of permanent successor teeth; influence arch integrity; alter speech development; promote the establishment of non-nutritive habits; and affect the child's aesthetic perceptions and quality of life.

The possible effects of premature loss of primary anterior teeth can be minimized through interventions, such as fixed aesthetic space maintainers, which can serve as an alternative for replacing missing anterior teeth. Although these appliances are used primarily for aesthetic purposes, they can also improve a child's mastication and phonation. Another appliance is the lower-lingual holding arch, commonly used to address mandibular canine losses. It is important to highlight that special care must be observed, including biofilm control with adequate oral hygiene and controlled diet.

Despite the abovementioned points, the authors of the present review would like to highlight that further controlled observational studies with higher methodological quality are needed to report issues such as the sequelae of premature loss of primary incisors and canines to the dental arch perimeter, speech pattern, oral function, aesthetics and quality of life. Additionally, interventional studies will likely assist in addressing this challenge by clearly elucidating the actual need for space-maintainer interventions made to provide both safe clinical practices and adequate management of the premature loss of primary anterior teeth.

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