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Enzyme replacement therapy with asfotase alfa in children with hypophosphatasia – safety and effectiveness: narrative review

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ABSTRACT

Hypophosphatasia is a metabolic illness caused by mutations in the ALPL gene, which lead to impaired bone mineralization and multiple whole-body complications, including premature tooth loss. The implementation of enzyme replacement treatment (ERT) with asfotase alfa has provided a substantial role in the management and prognosis of children with hypophosphatasia. This review shows current data on the efficiency, safety, and limitations of ERT with asfotase alfa in pediatric patients. The literature search was conducted on PubMed. Articles were published between 2015 and 2025. Special attention was given to clinical studies, case reports, and review articles that included pediatric patients with hypophosphatasia who were enrolled in enzyme replacement therapy with asfotase alfa. The available evidence shows that asfotase alfa improves survival, bone mineralization, and quality of life. The ERT, moreover, ameliorates respiratory symptoms and mobility problems, especially in perinatal and infantile forms of hypophosphatasia. Early treatment yields better clinical outcomes. The therapy is generally well tolerated, and adverse effects are mostly mild. At the same time, there are some important unresolved issues, including limited long-term safety data and differences in therapy response. The treatment carries potential for immunogenicity. Unfortunately, scientists cannot specify the exact dosage of medicine and how long patients should be treated with it. Asfotase alfa is an effective and moderately safe treatment option for children with HPP. More research is needed to assess the long-term safety profile of outcomes. This is very important to find proper doses.

Keywords: hypophosphatasia, childhood hypophosphatasia, infantile hypophosphatasia, perinatal hypophosphatasia, odontohypophosphatasia, enzyme replacement therapy with asfotase alfa.

1. INTRODUCTION

Hypophosphatasia is a genetic metabolic illness. Mutations in the ALPL gene are the main cause of that disease. This gene encodes an enzyme - tissue-nonspecific

alkaline phosphatase (TNSALP). It is responsible for the mineralization of the teeth and bones and for maintaining phosphate balance in the human body (Seefried, 2023).

As a result of these mutations, TNSALP activity is reduced. It plays a significant role in the hydrolysis of extracellular inorganic pyrophosphate (PPi), an inhibitor of bone mineralization. Alkaline phosphatase also converts extracellular pyridoxal-5'-phosphate (PLP, the main active form of vitamin B6) into pyridoxal, which is an essential cofactor in the synthesis of many enzymes involved in the metabolism of neurotransmitters, such as gamma-aminobutyric acid (GABA) (Millán and Whyte, 2016).

Hypophosphatasia is a disease that can affect many organs and systems, especially the bones and neurological system. The severity of that illness depends on the clinical forms. The most severe are perinatal and infantile. However, childhood form and odontohypophosphatasia are mild. Nephrocalcinosis and chondrocalcinosis can result from hypercalcemia and hypercalciuria. Neurological symptoms include irritability and pyridoxine-responsive seizures. Skeletal deformities are also commonly observed (D'Angelo et al., 2025).

For many years, hypophosphatasia was treated symptomatically with nonsteroidal anti-inflammatory drugs, physiotherapy, orthopedic procedures, dental care, and supplementation with vitamin D3 and calcium. A breakthrough in the treatment of this rare disease was the introduction of enzyme replacement therapy (ERT) with subcutaneous injections of alkaline phosphatase. This has led to a significant improvement in prognosis, particularly among the pediatric population. Several clinical studies have demonstrated improved bone mineralization, reduced bone and muscle pain, and better general well-being and daily functioning in patients. It has also been shown that earlier initiation of therapy is associated with improved clinical outcomes (Whyte et al., 2016a). This review article aims to summarize the efficacy, safety, and limitations of asfotase alfa therapy in pediatric patients.

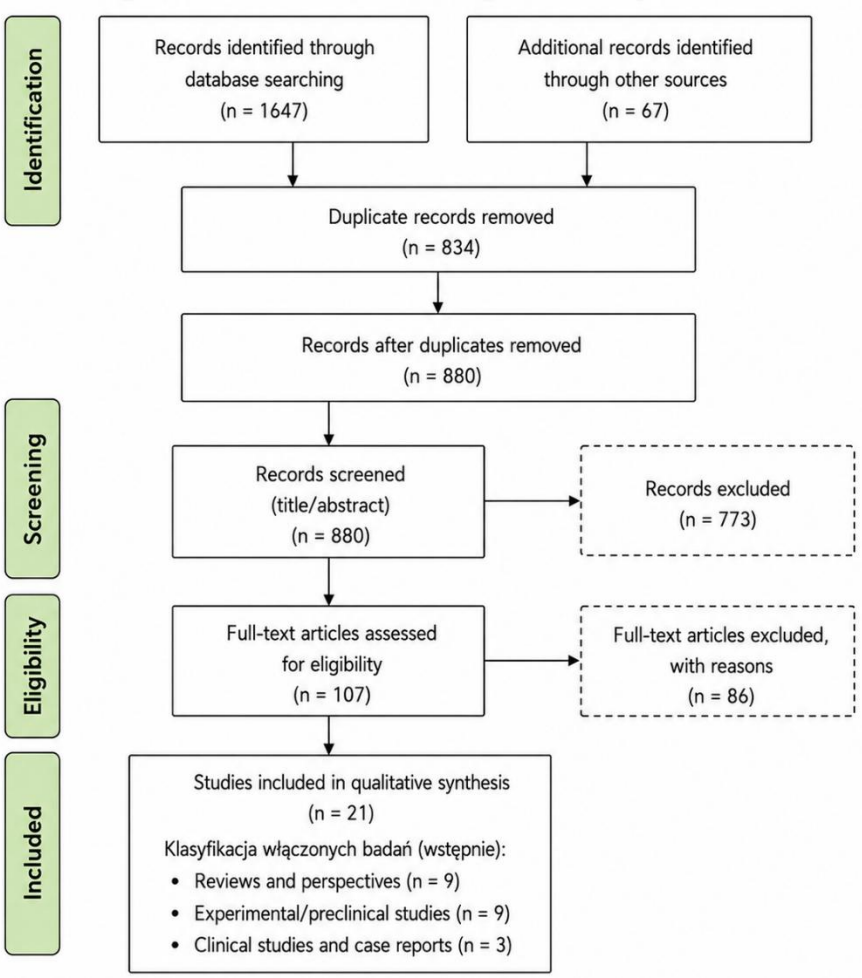

Figure 1. Prisma 2020 flow diagram of study selection.

2. REVIEW METHODS

This descriptive review is based on articles available in the PubMed database. We focused on articles published from 2015 to 2025. The literature search included studies investigating enzyme replacement therapy with asfotase alfa for the treatment of hypophosphatasia in the pediatric population. The following keywords were used: hypophosphatasia, childhood hypophosphatasia, infantile hypophosphatasia, perinatal hypophosphatasia, odontohypophosphatasia, and enzyme replacement therapy with asfotase alfa. Boolean operators (AND, OR) were applied to improve the search strategy.

We selected articles that are relevant to this review. Our inclusion criteria comprised original research articles, clinical case reports, and review articles addressing hypophosphatasia and/or enzyme replacement therapy with asfotase alfa in pediatric patients. Exclusion criteria comprised duplicate publications, articles unrelated to hypophosphatasia, and studies involving adults diagnosed with hypophosphatasia. In addition to publications identified in the PubMed database, related articles suggested by the database were also included. Its reference lists were screened to identify additional pertinent sources and expand the scope of the discussion.

Most of the included studies were published in English. Overall, the literature review comprised experimental studies, review articles, and clinical case reports relevant to this work. This is a narrative literature review. The article screening process followed the PRISMA 2020 guidelines (Figure 1).

3. RESULTS AND DISCUSSION

Effectiveness of enzyme replacement therapy (ERT) with asfotase alfa

The efficacy of enzyme replacement therapy with asfotase alfa in patients with hypophosphatasia is assessed by radiographic evaluation of bone and improvement in clinical symptoms. In the perinatal and infantile periods, treatment efficacy is evaluated by prolonged survival, improved respiratory function, enhanced growth and development, reduced severity of skeletal symptoms, improved psychomotor development, and better seizure control. After the first year of life, the evaluation of treatment efficacy includes improvements in motor function, reduction in skeletal manifestations, enhanced growth, improved psychomotor development, and prevention of nephrocalcinosis (Michigami et al., 2020).

Clinical studies have demonstrated that enzyme replacement therapy (ERT) in infants and children with severe forms of hypophosphatasia increased five-year survival from 27% (historical cohort) to 84% (treated cohort). Additionally, patients showed resolution of rickets-related symptoms and reduced bone demineralization on radiographic imaging (Whyte et al., 2016b). Radiographic improvements observed during asfotase alfa treatment include enhanced rib mineralization, improved chest structure and thoracic volume, as well as better ventilatory function in infants with hypophosphatasia. These changes can be assessed using the Radiographic Global Impression of Change (RGI-C) scale (Whyte et al., 2018).

Quality of life and improvement of motor function

Studies evaluating motor function in children and adolescents with hypophosphatasia treated with asfotase alfa demonstrated sustained improvement in walking ability measured by the 6-minute walk test (6MWT). An increase in walking distance and age-predicted percentage values was observed. These effects were maintained during long-term follow-up and exceeded the threshold for a clinically meaningful change at multiple time points (Petković Ramadža et al., 2025).

Similarly, improvements in motor development, as assessed using the BAMF scale, were observed in both upper- and lower-limb function. Higher scores indicated greater mobility and gross motor skills, particularly among patients who initiated treatment at an early age. In some cases, stabilization or further improvement was observed over long-term follow-up in both treatment-naive and previously treated patients (Padidela et al., 2025).

The observed effects were maintained during long-term follow-up. At multiple time points, they exceeded the threshold, considered a clinically meaningful change.

Safety and adverse effects

Asfotase alfa was generally well tolerated by most patients. All of them experienced at least one treatment-emergent adverse event. However, most events were mild to moderate in severity and were considered unrelated to the therapy. The most common adverse events included injection-site reactions, such as erythema, induration, discoloration, and hematoma. Mild systemic symptoms were also reported, including fever and upper respiratory tract infections (Hofmann et al., 2019). More serious complications were rare. No cases of serious adverse events directly related to the drug were reported (Sugiyama et al., 2022; Rush, 2018).

Impact on oral health status

Treatment with asfotase alfa affects not only long bones but also the teeth, alveolar bone, and periodontium in hypophosphatasia. One of the main benefits of dental and periodontal health is a lower rate of premature loss of primary teeth in children treated from infancy compared with those who initiated ERT later (mean 1.8 vs 10.2 teeth lost) (Khan et al., 2025; Seefried et al., 2025). Early initiation of enzyme replacement therapy (ERT) reduces the risk of premature loss of primary teeth and improves dental health in children with hypophosphatasia (Okawa et al., 2021; Simmons et al., 2020).

Histological studies of teeth in children with hypophosphatasia have shown slight improvements in the mineralization of cementum and dentin during therapy. However, these changes are less pronounced than those observed in the skeleton (Wölfel et al., 2023). Nevertheless, clinical observations suggest that ERT may contribute to normalization of delayed dental age, increased mandibular bone density, and stabilization of periodontal status, without progression of periodontal pocketing, in some pediatric patients (Okawa et al., 2021; Šumník and Souček, 2023).

On the other hand, some patients were continuing to experience loss of already mobile teeth or premature loss of several teeth after treatment initiation. In addition, improvements in dental tissue mineralization are often modest and slow, likely reflecting the limited remodeling capacity of dentin and cementum (Wölfel et al., 2023; Vogt et al., 2020). Evidence from clinical trials, registries, and systematic reviews indicates that asfotase alfa represents a major advance in the treatment of hypophosphatasia, especially in severe, early-onset forms. Table 1 summarizes the main findings of the studies included in this narrative review.

Table 1. Summary of the main studies evaluating the effectiveness and safety of asfotase alfa in pediatric hypophosphatasia.

Study	Population	Main findings	Safety
Whyte et al., 2016	Children with perinatal/infantile HPP	Improved survival, bone mineralization, respiratory function	Generally, well tolerated
Hofmann et al., 2019	Infants and young children	Clinical and radiographic improvement	Mostly mild injection-site reactions
Sugiyama et al., 2022	Japanese pediatric cohort	Effective in routine practice	No unexpected serious adverse events
Padidela et al., 2025	Children/adolescents	Improved mobility and quality of life	Favorable long-term safety
Khan et al., 2025	Review of clinical evidence	Benefits across skeletal and dental outcomes	Good overall safety profile

The greatest benefits are seen in patients with perinatal and infantile HPP. In these groups, enzyme replacement therapy (ERT) improves survival, bone mineralization, breathing, and motor development (Khan et al., 2025). These effects are not only short-term. Studies show that improvements can last for 5–7 years, including catch-up growth and, in many cases, the ability to stop respiratory support (Padidela et al., 2025).

Patients with milder forms of hypophosphatasia experienced improvement. Studies in children with childhood-onset HPP reported lower pain levels, better physical function, and improved quality of life (Padidela et al., 2025). This shows that decisions about therapy should be individualized and not limited only to the most severe cases.

The timing of treatment is very important. Starting ERT early—before severe bone damage or respiratory problems develop—leads to better outcomes. Children treated early show better growth and motor function and have a lower risk of respiratory failure. Early treatment may also reduce dental problems, such as early loss of primary teeth. On the other hand, starting treatment late or interrupting it may limit its effectiveness. Some changes, such as lung hypoplasia, may not fully reverse, and stopping therapy can lead to a return of poor bone mineralization (Whyte et al., 2016a).

Asfotase alfa is generally well tolerated by patients. Some children experienced reactions at the injection site, temporary fever, and upper respiratory infections. There are mild side effects. Craniosynostosis and pneumonia have been reported after longer observation. Serious side effects are rare, but they could be allergic reactions or hepatitis. Ectopic calcifications have been seen in both treated and untreated patients, so it is difficult to determine whether the drug causes them (Khan et al., 2025).

Immunogenicity is an area of growing interest. Some patients develop neutralizing antibodies (NAbs), which may reduce treatment effectiveness. This seems to be more common in patients with more severe diseases. There is some evidence linking NAbs to a weaker radiological response, but the data remains limited. There are no clear guidelines for monitoring or managing this issue. Treatment response may also depend on the type of ALPL mutation and the level of enzyme deficiency. More research is needed in this area (Dahir & Dunbar, 2025).

It is also not known whether patients with milder disease or adolescents need the same treatment intensity as severely affected infants. The ideal duration of treatment is also uncertain. Evidence suggests that therapy should be continued, as stopping it may worsen the disease (D'Angelo et al., 2025). Long-term safety data beyond 10 years are still lacking. This is especially important for patients who start treatment in early childhood and continue into adulthood. Long-term follow-up studies and patient registries are needed to better understand the long-term effects of asfotase alfa therapy.

Practical and ethical issues also need to be considered. The treatment is very expensive, and HPP can vary widely in severity. This makes decisions about whom to treat and when to start or stop therapy difficult. Current recommendations suggest treating patients with clear clinical symptoms, such as pain, limited mobility, rickets, growth problems, or life-threatening complications (Padidela et al., 2025). However, the balance between benefits, risks, and costs is still being defined.

Asfotase alfa is an effective and generally safe treatment for HPP, especially in severe early-onset cases. Early and continuous treatment seems to give the best results. However, more research is needed to define optimal treatment strategies, assess long-term safety, and understand differences in patient response (Martos-Moreno et al., 2023).

4. CONCLUSION

Asfotase alfa has significantly improved the management of hypophosphatasia in children, particularly in severe early-onset forms. The therapy leads to better survival, improved bone mineralization, enhanced motor function, and improved quality of life. Early initiation and continuous treatment appear to be key factors for achieving optimal clinical outcomes. The therapy is generally well tolerated, and most adverse effects are mild. Further research and long-term observational studies are needed to optimize treatment strategies, identify patients who are most likely to benefit from therapy, and evaluate the long-term effects of asfotase alfa in both pediatric and adult populations. Research should focus on optimal doses and treatment duration. It remains to be determined how patients with gene mutations will respond and what the impact of immunogenicity will be.

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Informed consent

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Conflict of interest

The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data and materials availability

All data associated with this study will be available based on the reasonable request to corresponding author.

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