Submitted: 13 December, 2022 Accepted: 06 January, 2023 Published: 03 September, 2024 DOI:10.22514/jocpd.2024.119

CASE REPORT

Journal of Clinical Pediatric Dentistry

Levels of B-ALP and TRAP-5b in a patient with short root anomaly: a case report

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Abstract

The purpose of this study was to observe the changes in bone-specific alkaline phosphatase (B-ALP) and tartrate-resistant acid phosphatase-5b (TRAP-5b) in a patient diagnosed with short root anomaly (SRA). The detailed clinical data and history of related clinical symptoms of the SRA patient were retrieved. Oral examination showed that the shape and color of the tooth crown were normal. Tooth 11 and 12 were missing, and the mobility degree of other teeth was II–III. Panoramic radiograph examination showed that the root length only reached the neck of the tooth. Laboratory results showed that blood spectrum, chromosome and trace elements were normal. Endocrinological evaluation indicated that hormone levels were within normal limits; however, both B-ALP and TRAP-5b were higher than the normal range. The present case shows that SRA may be related to an imbalance in osteoblast/osteoclast metabolism, which provides a new direction for the etiological research of this disease.

Keywords

Short root anomaly; Clinical examination; Laboratory test; Osteoclast; Osteoblast

1. Introduction

The incidence of short root anomaly (SRA) is about 1%–10% in deciduous and permanent dentition, which might result in non-root, short-root, and early teeth shedding [1]. Although its occurrence has been attributed to genetic disease, systemic disease, traumatic factors and treatment, the real pathogenesis remains poorly understood. Recent studies have shown that the formation of tooth roots is limited in mice with weakened osteoclast activity, and early shedding cannot occur after administration of the original osteoclast particles, indicating that osteoclasts play an important role in the formation of tooth roots [2, 3]. It is believed that the main function of osteoclasts is to absorb alveolar bone in the development of tooth roots to form a pathway for the downward growth of the tooth root. Osteoblasts must be considered when studying osteoclasts because bone metabolic transformation involves two opposite and interrelated processes: osteoblasts-mediated bone formation and osteoclasts-mediated bone resorption. Only osteoblasts and osteoclasts maintain a dynamic balance, to ensure the normal physiological function of bones [4]. The objective of this present study was to provide a new perspective on the etiology of root dysplasia by analyzing the specific indexes of abnormal bone metabolism in a patient with SRA.

2. Case report

Here, we report the case of a 17-year old male patient with persistent occlusal discomfort and weak chewing since the replacement of deciduous teeth. One month ago, the patient came to our department to treat upper anterior teeth loss. Detailed verbal descriptions regarding the research objectives and relevant procedures were provided, informed consent was obtained from the patient and his parents.

The proband verification method was adopted to design an investigation questionnaire, to inquire about the family members' history of present diseases, systemic diseases, fetal, and infant disease history and drug exposure history. The general health status and oral specialty examination of the family members were conducted to understand the corresponding medical history and genetic characteristics of any family-related diseases. The age, gender, clinical manifestations and X-ray data of the patient were recorded and analyzed. His blood spectrum, chromosome, trace elements and hormone levels, including B-ALP and TRAP-5b were analyzed in our laboratory.

The detection of B-ALP and TRAP-5b was performed according to the instructions of the human chemiluminescence kit and previously described [5]. Briefly, 5 mL venous blood was extracted from the patient under a fasting state, which was then centrifuged at 3500 r/min for 15 min, and the serum was absorbed. An automatic chemiluminescence detector was used to measure the serum levels of B-ALP and TRAP-5b.

Our analysis showed that no similar symptoms in the family, and the family history revealed no consanguineous marriage between his parents. According to his mother, the patient was born after an uneventful, full-term pregnancy with no exposure to radiation. Physical examination showed that the patient was moderately developed, with intellectual develop-

ment consistent with his age, and normal bones, muscles, and skin development. The oral hygiene was general, contained biofilm without dental calculus, and no obvious congestive redness and swelling were found in the gums. The shape and color of the permanent tooth crown were normal. Teeth 11 and 12 were lost, and no third molars were seen. The mobility degree of the other teeth was II–III. Panoramic radiograph examination (Fig. 1) showed no third molars embryo, the teeth roots were short to varying degrees with low-density images around periapical tissue, and the crowns did not contain a pulp chamber. Chromosome analysis showed that the patient was male, his autosomal number was 44, sex chromosome number was 2, chromosome karyotype was 46 XY, and no number or structure aberration was observed. The serum trace elements and hormone levels were also normal. However, B-ALP: 26.77 μg/L (reference value: 8–16.6 μg/L) and TRAP-5b: 13.3 U/L (reference value: <4.85 U/L) levels were all higher than normal (Table 1).

3. Discussion

SRA is a disorder associated with the physiological development of tooth roots, without affecting tooth crown development. Although it is usually characterized by root absence or short roots, premature tooth loss may occur in severe cases. SRA has been known to occur in humans due to various genetic and environmental factors [6, 7]. The simultaneous presence of multiple dental anomalies was previously reported, especially in patients with chromosomal alterations, which have been associated with multi-systemic alterations. Despite some reported cases of multiple dental anomalies within families, some were observed in individuals with no family history [8, 9]. For this present case, we conducted blood spectrum, chromosome, serum trace elements, hormone levels and other tests. The results showed a significant increase in B-ALP and TRAP-5b but no abnormalities in other indicators, indicating that SRA might be related to abnormal bone metabolic transformation, thereby providing a novel perspective on its etiology.

Bone homeostasis is mainly maintained by the coordinated activities of bone formation, mediated by osteoblasts, and bone resorption, mediated by osteoclasts [10]. Perturbation in these coordinated activities can lead to profound alterations in bone mass. During bone tissue reconstruction, the bone matrix is continuously generated and broken down, leading to some relatively specific matrix products, enzymes and lysates entering the blood or urine, making them good biochemical markers of bone conversion [11, 12]. Many studies have shown that B-ALP is an effective marker able to reflect the activity of osteoblasts and bone formation, and TRAP-5b, as a second-generation bone resorptive marker, is a specific and highly sensitive bone resorptive indicator. When both functions of absorption and formation in the process of bone reconstruction are hyperactive, this results in high conversion of bone damage [13, 14]. However, some scholars have expressed different views, suggesting that osteoclasts confirmed

FIGURE 1. Panoramic radiograph examination showing no third molars embryo, loss of teeth 11 and 12, and varying degrees of short roots of other teeth with low-density images around the periapical tissues. Additionally, the crowns did not contain a pulp chamber.

TABLE 1. Serum B-ALP, TRAP-5b values.

Index of detection	Measured value	Reference value	Numerical value index
B-ALP	26.77 µg/L	8–6.6 µg/L	elevated
TRAP-5b	13.3 U/L	<4.85 U/L	elevated

B-ALP: bone-specific alkaline phosphatase; TRAP-5b: tartrate-resistant acid phosphatase-5b.

by TRAP protein expression may not directly correlate with active bone resorption. Previous studies have shown that osteoclasts must adhere to the bone surface to resorb bones, and non-attached osteoclasts identified on are not functional "bone eaters" [15]. Although these non-attached osteoclasts do not degrade bones, they perform important functions in bone/root remodeling. Nevertheless, information about non-attached osteoclasts would only be possible in a histopathological evaluation, which has limitations to be performed in a clinical study [16]. In this present case, both B-ALP and TRAP-5b values were higher than the normal reference value, indicating a high metabolic type with osteoclasts and osteoblasts in an active state. More studies are needed to determine why the hyper-metabolic status of bone in this patient only caused abnormal root development and had no effect on tooth eruption. Based on the reports from studies of other scholars, we hypothesize that the increase in TRAP-5b level in this patient might be directly related to the reabsorption process. However, there has been a lack of studies on the relationship between osteoclast and osteoblast transformation in SRA patients in literature. Here, we report the changes between osteoclasts and osteoblasts in an SRA patient by analyzing specific enzymes in bone metabolism, which provides a new direction for further research.

Teeth, represent an excellent model for studying organogenesis. They develop from a series of epithelial-mesenchymal interactions mediated by a complex molecular network [17–19]. Studies on teeth loss in patients with hypophosphatasia found that the effects of low B-ALP affected not only the cementum and dentin, but also the proliferation and differentiation of pulp cells. They also discovered that hypophosphatase cells were characterized by an overall weak biological behavior and that the dentin formed during teeth development was relatively thin [20, 21]. However, in this study, although the radiographs showed signs of dentin dysplasia and no pulp cavity, the B-ALP value was higher than normal. Thus, it cannot be explained by the above reasons but reminds us that when B-ALP is too high or too low, it may cause developmental disorders of teeth. Root development is an important stage for later tooth development. The ordered coordination between the superior cervical ring stem cell niche, mesenchymal dental capsule and dental papilla stem cell niche determines the development process of a tooth root. An abnormal link without other compensatory factors could lead to root dysplasia [22, 23]. It was shown that root growth can produce a force that causes bone resorption at the base of the crypt bone, but does not cause tooth eruption to move, indicating the possible implication of other mechanisms coordinating tooth movement with root growth.

In contrast to the roles of osteoclast-mediated bone resorption in tooth eruption, the significance of osteoclasts in tooth root formation is less well-defined [24–26]. The results of some studies support the hypotheses that osteoclast defects disrupt the development and growth of tooth roots. The homeostatic perturbation of odontogenic precursors central to the root formation of mouse incisors is the primary cause of odontoma-like proliferations in new mutants. It was also demonstrated that osteoclasts play an essential role in root formation. However, the above studies suggested that the main role of osteoclasts is to absorb alveolar bone during tooth root development and to form a channel for the downward growth of tooth roots [27]. However, it remains unclear whether osteoclasts are needed in the development and formation of tooth roots. Our results showed that osteoclasts were active, indicating that they could form alveolar bone absorption channels and promote the downward growth of tooth roots. The limitation of tooth root formation might not be caused by the decreased activity of osteoclasts, suggesting that there might be other reasons for the failure of root formation in the patient reported in this study.

4. Conclusion

The specific indexes of bone metabolism, B-ALP and TRAP-5b, in our reported SRA patient were higher than normal values, suggesting the possibility of exploring root development mechanism from the perspective of bone metabolism balance, thus providing a new research concept for the prevention and treatment of SRA.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

HQ, YQG—designed the research study, analyzed the data. HQ—performed the research, wrote the manuscript. Both authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All procedures of this study were carried out in accordance with relevant guidelines and approved by the Lianyungang Affiliated Hospital of Xuzhou Medical University/Lianyungang First People's Hospital (Grant number: LW-20221228001-01). And the informed consent was obtained from the patient and his parents.

ACKNOWLEDGMENT

The authors are grateful to the patient and his family members for their kind cooperation and participation.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Han Qin, Yong-qing Gong. Levels of B-ALP and TRAP-5b in a patient with short root anomaly: a case report. Journal of Clinical Pediatric Dentistry. 2024; 48(5): 189-192. doi: 10.22514/jocpd.2024.119.