CASE REPORT

Challenges in the Orthodontic Treatment of a Patient With Pycnodysostosis

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Pycnodysostosis is a rare, autosomal recessive syndrome characterized by osteosclerosis, brittle bones, stunting, and significant craniofacial changes. The objective of this study was to report a case of a 6-year-old patient with pycnodysostosis orthodontically treated and followed up until age 10 years and to discuss the risk factors, options for orthodontic treatment, and limitations involving this type of treatment, which has not yet been performed. Prevention through counseling and periodic follow-up visits is essential in eliminating factors that predispose patients to infections and fractures. New studies are necessary to establish safe and efficient orthodontic treatment plans.

KEY WORDS: pycnodysostosis, bone dysplasia, craniofacial changes

Pycnodysostosis (PYCD) is an autosomal recessive osteosclerotic skeletal dysplasia characterized by susceptibility to fractures, short stature, delayed closure of the fontanels, wide lambdoidal sutures and premature synostosis of the coronal suture, craniofacial abnormalities clavicular dysplasia spondylolysis, and acroosteolysis (Maroteaux and Lamy, 1962; Warman et al., 2011). Although the precise incidence of PYCD is unknown, it is considered a rare disorder, affecting different ethnicities, whereas consanguinity has been reported on several occasions. Loss-of-function mutations in the cathepsin K gene (CSTK), spread throughout the whole gene, are the genetic background underlying the disorder. The mutations p.A227V and p.R241X are the most common ones and both are located in the mature domain of the polypeptide (Hou et al., 1999; Donnarumma et al., 2007; Bertola et al., 2010). Physiologically, the enzyme cathepsin K plays an important role in bone reabsorption. The defective enzyme does not degrade the organic matrix and therefore hampers bone remodeling, resulting in increased bone density and volume, sclerosis, brittleness, and greater susceptibility to fractures (Everts et al., 2006; Li et al., 2006).

Oral findings include delayed tooth formation and eruption process, short and poorly shaped roots, micrognathia with an obtuse mandibular angle, deep and narrow palates, and, consequently, malocclusion, including crossbite, anterior open bite, and crowding. Poor oral hygiene, periodontal disease, and dental caries are common. Affected patients are susceptible to pathological fractures and osteomyelitis of the maxillary bones. Orofacial changes increase the morbidity and mortality associated with PYCD (Maroteaux and Lamy, 1962; Francisco and Nicholoff, 1991; Iwu, 1991; Muto et al., 1991; Hunt et al., 1998; O’Connell et al., 1998; Alibhai et al., 1999; Fonteles et al., 2007). Currently, there is no consistent information or recommendation in the literature on the orthopedic or orthodontic treatment of patients with PYCD; therefore, the objective of this study was to report the general and craniofacial features, orthodontic procedures, and risk factors in a patient with PYCD.

CASE REPORT

The patient is a 13-year-old girl, the firstborn child of nonconsanguineous parents, showing short stature, typical facial features (high forehead, midface hypoplasia, shallow orbits, high nasal bridge and root, bulbous nose tip, prominent cheeks, micrognathia), short fingers with excessive skin, and a history of recurrent bone fractures. An ear, nose, and throat (ENT) evaluation was performed because of excessive snoring for the past 3 years, and an examination of the airways and polysomnography showed no obstructions and/or episodes of apnea. As the clinical findings were suggestive of PYCD, a skeletal survey was performed showing high bone density, wide cranial sutures, persistent open fontanelles, hypoplastic paranasal sinuses, hypoplasia of the acromial extremity of the clavicle, and acroosteolysis. Furthermore, the bidirectional sequencing of the coding region of the CSTK gene revealing the presence of c.721C>T (p.Arg241X)/c.83dupT confirmed...
the clinical diagnosis of PYCD. This last gene alteration is novel.

At age 6 years 9 months, the patient was referred to the dental division. After her medical history had been obtained and examination of her oral cavity had been performed, she underwent clinical, photographic, radiographic, and cephalometric craniofacial assessments (Fig. 1A through 1E).

Intraoral examination revealed mixed dentition, poor oral hygiene, periodontal disease, dental caries, maxillary atresia, a deep and narrow palate, crowding, deviation of the lower midline to the right, anterior and posterior crossbite, and anterior open bite.

Radiographic assessment (panoramic and lateral cephalometric radiographs) revealed an abnormal sella turcica, maxillary and mandibular hypoplasia, obtuse mandibular angles, short mandibular rami, elongated coronoid and condyloid processes, agenesis of the second lower premolars, disappearance of the lamina dura, interdental alveolar crest resorption, and short, poorly shaped roots.

Cephalometric analyses confirmed the skeletal diagnosis of the patient (Table 1).

The treatment plan for the patient consisted of restoration and periodontal treatment, serial extractions to reduce crowding, and correction of the abnormal eruption sequence secondary to PYCD. Prior to the extractions, the patient was prophylactically treated with antibiotics to prevent osteomyelitis. No infections resulted from the extractions, and healing was normal. An upper removable orthodontic appliance with central expander, occlusal coverage, and rotating springs (from ages 7 to 9 years) followed by a functional Fränkel III appliance (from ages 9 to 10 years) was used to expand the maxilla slowly and remodel the tissues; however, the attempt was not successful (Fig. 2A and 2B).

Currently, the patient is using upper and lower removable appliances with an expander and rotating springs to rotate the incisor teeth and improve the dental alignment. She follows up once monthly, and a radiograph is taken every semester to control the root formation of the lower right first bicuspid tooth and the first permanent molar on the same side (Fig. 3A through 3D). As soon as the permanent dentition is complete, the next steps to align the teeth will be planned (extractions and appliances).

**DISCUSSION**

There are few reports in the dental literature about the cephalometric diagnosis of patients with PYCD that describe occlusal and craniofacial characteristics (Fukada et al., 1967; Takeuchi et al., 1980; Hunt et al., 1998; Norholt et al., 2004; Fonteles et al., 2007).

The cephalometric diagnosis of the studied patient was skeletal class II with mandibular retrusion, clockwise rotation of the mandible, short maxillary and mandibular lengths, short anterior and posterior cranial bases, short anterior and posterior facial heights, clockwise-growth tendency, and protruded and proclined upper and lower incisors. Although the clinical aspects showed anterior crossbite, the association between facial analysis, intraoral

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observations, and cephalometric analysis are essential for the correct diagnosis and treatment plan.

According to Green and Rowe (1976), patients with PYCD are brachycephalic; however, some authors report dolichocephaly (Takeuchi et al., 1980; Muto et al., 1991; Francisco and Nicholoff, 1991). The craniofacial pattern in the above-mentioned studies was determined through facial analysis, radiographs, and isolated cephalometric measurements. In the present study, these analyses were complemented by the VERT index (vertical facial growth coefficient; Ricketts, 1975), showing that this patient presents with dolichocephaly. The craniofacial pattern is influenced by genetic and hereditary characteristics, and the wrong timing of the closure of the cranial sutures in part explains the conformational changes of the skull and differences in the facial pattern of patients with PYCD (Bertola et al., 2010).

The maxillary and mandibular lengths of the present case were shorter than usual according to the Co-A, Go-Me, and Co-Gn measurements. This shortness can have a strong impact on the pharyngeal airspace because the sagittal hypoplasia of the bone bases may have led to glossoptosis, which caused narrowing of the airways, confirmed by measurements of the upper and lower pharyngeal space (Table 1). This may explain the patient’s snoring for the past 3 years.

One of the patients presented by O’Connell et al. (1998), who was diagnosed with obstructive sleep apnea (OSA), continues to require continuous positive airway pressure after uvulopalatopharyngoplasty and adenoidectomy. Patients with PYCD should see an otorhinolaryngologist during early childhood for early diagnosis of OSA based on a comprehensive assessment including airway examination and polysomnography because improved ventilation and reduced snoring have a positive effect on the growth and development of the maxillomandibular complex. Our patient was properly assessed by the ENT department, which found no obstructions and/or episodes of apnea.

Currently, there is no consistent information or recommendation in the literature on the orthopedic or orthodontic treatment of children and adults with PYCD. It is known that these treatments are completely dependent on osteoclastic activity, bone resorption, and remodeling capacity. Naturally, children should be submitted as soon as possible to orthodontic treatment to correct malocclusion or minimize skeletal problems.

Given the severity of skeletal malocclusion, many cases require orthodontic treatment associated with orthognathic surgery in adulthood. According to Norholt et al. (2004) and Varol et al. (2011), conventional orthognathic surgery should not be considered for patients with PYCD because of an increased risk of infection due to bone graft and fixation with plates and screws. Extraoral distraction osteogenesis could minimize the risk of infection and promote the desired movement, as seen in their 15- and 33-year-old patients, respectively, who underwent maxillary distraction osteogenesis. There were no intercurrences during the 12-month follow-up.

| TABLE 1 Cephalometric Measurements of the Patient With Pycnodysostosis Aged 6 Years 9 Months |
|-----------------------------------------------|-----------------|------------------|
| Cephalometric Measurement                      | Case Reference  | Data             |
| Sagittal measurements                          |                 |                  |
| Maxillary convexity (mm)                       | 6.6             | 1.9 ± 2.0*       |
| Maxillary depth (°)                            | 95.1            | 90.0 ± 3.0*      |
| Facial depth (°)                               | 86.2            | 87.3 ± 3.0*      |
| Anterior cranial base length (S-N) (mm)        | 58.1            | 71.0 ± 3t        |
| Distance between sella and articular (S-Ar) (mm)| 20.5           | 32.0 ± 3t        |
| Distance from condylion to point A (Co-A) (mm) | 71.3            | 93.6 ± 3.2t      |
| SN to mandibular plane (Go-Me) (mm)            | 52.3            | 67.0 ± 2.7*      |
| Mandibular length (Co-Gn) (mm)                 | 80.3            | 97 a 100‡        |
| Vertical measurements                          |                 |                  |
| Mandibular plane (°)                           | 37.3            | 25.8 ± 4.0*      |
| Anterior face height (N-Me) (mm)               | 86.8            | 105 ± 120†       |
| Posterior face height (S-Go) (mm)              | 47.0            | 70 ± 85†         |
| Face axis (°)                                  | 91.7            | 90.0 ± 3.0*      |
| VERT index                                     |                 |                  |
| Face axis (°)                                  | 91.7            | 90.0 ± 3.0*      |
| Facial depth (°)                               | 86.2            | 87.3 ± 3.0*      |
| Mandibular plane (°)                           | 37.3            | 25.8 ± 4.0*      |
| Lower face height (°)                          | 46.6            | 47.0 ± 4.0*      |
| Mandibular arc (°)                             | −3.3            | 26.6 ± 4.0*      |
| VERT                                          | −2.01           |                  |
| Airways measurements                           |                 |                  |
| Upper pharyngeal space (adenoid) (mm)          | 4               | >5‡              |
| Lower pharyngeal space (tonsils) (mm)          | 7               | 11–14‡           |

* Ricketts (1975).
† Jarabak and Fizzell (1972).
‡ McNamara (1984).

Given the malocclusion of the present case (maxillary atresia, no space for teeth eruption, and severe anterior and posterior crossbite), the ideal treatment would be maxillary disjunction through a combined use of rapid maxillary expansion and face mask (da Silva Filho et al., 1998), followed by retention with Fränkel III appliance (Levin et al., 2008). Maxillary disjunction leads to a real gain in bone mass, thereby resulting in increased dental arch perimeter (Hass, 1980), but there are no data in the literature about the safety and efficacy of this treatment in patients with PYCD.

When the expansion screw is turned, a force is exerted upon the teeth and the palate. This force is required for overcoming the resistance of the bone and suture, separating the maxillary and palatine processes in the median palatine suture region. Because of the osteosclerosis and bone brittleness associated with PYCD, there could be an increased risk of nonrupture of the median palatine suture, fracture of the alveolar rims, loss of teeth, and maxillary osteomyelitis.

If maxillary disjunction occurred in the studied patient, how would the bone remodeling in the median palatine suture region occur? It could result in a generalized increase in bone density and volume, osteosclerosis, reduced medullary space, and increased brittleness, making the area very vulnerable to pathological fractures or maxillary osteomyelitis according to some in vitro studies (Everts et al., 2006; Li et al., 2006).

Considering the facts discussed above, particularly the risks of osteomyelitis and the doubts about palatine suture rupture and bone formation, instead of treating with rapid maxillary expansion associated with face mask, we opted for serial extraction and other removable appliances to guide the teeth eruption and rotate the incisor teeth. Corrective orthodontic treatment through a fixed orthodontic appliance is contraindicated, considering root abnormalities and bone loss, as the response to these treatments has not been studied yet. Hence, the results obtained with the proposed treatments to correct malocclusion are limited, and the prognosis is poor. However, the improved positioning of teeth achieved by serial extractions, an upper removable appliance with springs, and periodontal control made oral hygiene easier and resulted in oral and systemic health.

Frequent dental visits for topical fluoride administration and encouraging good oral hygiene practice to prevent infections are very important.

New in vitro and in vivo studies in animals, and eventually in humans, are necessary to determine the impact of orthodontic procedures on osteoclast cell response, bone metabolism, and tissue repair of individuals with PYCD. In these cases, an upper removable appliance with springs associated with serial extractions was safe for teeth movement, but other orthodontic treatments such as rapid maxillary expansion, maxillary protraction, and fixed orthodontic appliances in these individuals can be performed safely only if more scientific information on the topic becomes available.

REFERENCES


