Orthodontic approach in patients with osteogenesis imperfecta

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Abstract

AThis review aims to investigate treatment strategies for patients diagnosed with osteogenesis imperfecta (OI). The article is based on a literature search on websites and scientific journals such as PubMed, the European Journal of Orthodontics, and the American Journal of Orthodontics. Orthodontic treatment has a positive impact on the oral cavity and adjacent structures. Patients with OI can undergo orthodontic treatment since these types of medications do not affect the incidence of osteonecrosis in children and adolescents. Orthognathic treatments in patients with OI who take bisphosphonates are longer, more intricate, and involve slower healing periods compared to treatments in healthy individuals. Indeed, treatment must be tailored based on the patient's age. Orthodontic treatments are necessary in patients with mixed dentition to facilitate the eruption of slower-developing teeth, such as canines, premolars, and second molars. For adult patients, it is essential to collaborate with the orthopedic doctor and develop comprehensive orthodontic, surgical, and prosthetic treatment plans. .
Keywords: Osteogenesis imperfecta, orthodontic therapy, orthognathic therapy, biphosphonates in orthodontics.

Introduction

Osteogenesis Imperfecta is a rare genetic disorder with autosomal transmission. It is characterized by an alteration in connective tissue, resulting in reduced formation, strength, and resistance of bone and other tissue structures. Therefore, it is also known as "brittle bone disease," as patients with this condition are highly likely to fracture due to lower bone density.
A classification of bone-related disorders was created and regularly updated in 1969 to facilitate communication among medical professionals and provide accurate diagnosis and treatment. The latest revision recognizes five types of Osteogenesis Imperfecta (OI) within the group "Osteogenesis Imperfecta and decreased bone density" (1):

- Osteogenesis Imperfecta Type 1, non-deforming form with persistent blue sclera or Van der Hoeve Syndrome.
- Osteogenesis Imperfecta Type 2, lethal perinatal form.
- Osteogenesis Imperfecta Type 3, progressively deforming form.
- Osteogenesis Imperfecta Type 4, moderate form.
- Osteogenesis Imperfecta Type 5, a calcified form of intraosseous membrane and/or hypertrophy of the bone callus.

OI can be autosomal dominant, autosomal recessive, or X-linked. It primarily involves mutations in the COL1A1 gene on chromosome 17q21.33 and COL1A2 on chromosome 7q21.3, encoding collagen type 1 alpha 1 and collagen type 1 alpha 2, major components of human body collagen.

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Collagen, a structural protein constituting cartilage, bones, tendons, skin, and the white part of the eye (sclera), forms a triple helical structure for effective communication. Collagen type 1 comprises two collagen alpha one chains and one collagen alpha two chain, with a glycine residue every three amino acids. OI is associated with a mutation in glycine, replaced by another amino acid.

In the case of Osteogenesis Imperfecta Type 1, a null allele, meaning it's devoid of information and functionality, is present in the COL1A1 gene. This genetic transmission error results in genetic haploinsufficiency, where the remaining allele is insufficient to preserve normal genetic function. Types 2, 3, and 4 involve a missense mutation. This can result in coding for a different amino acid, usually glycine, producing a different protein or a junction site mutation involving inserting, modifying, or deleting nucleotide parts during mRNA maturation. These mutations result in mild, moderate, or lethal forms of OI (2).

These mutations lead to incorrect collagen production, causing improper bone, tendon, and muscle formation. Patients with this condition have an increased tendency for fractures, which are less frequent in childhood and more frequent in late adolescence and adulthood. Due to the tissue connective deficit, these patients exhibit a gray-blue sclera, revealing underlying blood vessels. Additionally, they may have dentinogenesis imperfecta type 1, a 50% chance of developing neurosensory hearing loss after 50, and joint hypermobility in adulthood (2,3).

Diagnosis relies on a clinical examination and, to confirm it, a histological examination. The initial investigation involves assessing family history, followed by an oral inspection to detect dentinogenesis imperfecta potentially confirmed with radiographs and bluish sclera. Subsequently, histological confirmation is essential. Fibroblast culture from the patient's skin examines the quantity and structure of type 1 procollagen molecules, a collagen type 1 precursor. Another examination involves extracting DNA from white blood cells to evaluate mutations in the COL1A1 and COL1A2 genes (3).

Dentinogenesis imperfecta type 1 associated with OI implies a structural weakness of dentin due to an incorrect proportion of minerals, obliteration of the pulp, calcified ectopic masses, scattered tubules, disorientation of collagen filaments, and a rough surface full of gaps (4).

Dentinogenesis Imperfecta type 1 affects tooth enamel as well as dentin. Regarding mineral composition, dentin exhibits increased carbon levels and decreased calcium and phosphate levels, while enamel shows a significant increase in carbon but a decrease in oxygen, phosphorus, and calcium levels (4).

Additional clinical signs related to the dental field include agenesis of certain dental elements and malocclusions. Various studies assert that the most common malocclusion in patients with Osteogenesis Imperfecta is Class III, followed by Class I and Class II. Moreover, the percentage of interincisal diastema is similar to that in a healthy population, and the condition does not impact facial symmetry. Jaw facial growth is slowed, increasing the likelihood of developing a reverse overjet, posterior crossbite, and anterior open bite. The probability of tooth loss is also elevated (5,6).

Materials & methods

The literature search was conducted through scientific platforms such as PubMed, the European Journal of Orthodontics, and the American Journal of Orthodontics. Eleven articles in the dental field were selected, applying the criterion of excluding articles older than 20 years, as scientific research has evolved and progressed in recent years. The chosen scientifically relevant literature was required to have keywords such as osteogenesis imperfecta, orthodontic and orthognathic therapy, and bisphosphonates. These studies involved selecting patients with an age range between 7 and 29 years, affected by osteogenesis imperfecta types I-III-IV. Genetic investigations demonstrated that most patients with this condition exhibited genetic mutations in the COL1A1 and COL1A2 genes.

Discussion

It is common knowledge among medical professionals, especially in dentistry, that a good or stable occlusion positively influences structures adjacent to the oral cavity. Therefore, orthodontic treatment has both aesthetic and functional purposes. Patients with OI often take antiresorptive agents like bisphosphonates to reduce the risk of fractures by increasing bone density. It entails a more challenging orthodontic treatment as it affects dental and orthodontic movement and the healing process of both jaws post-orthognathic surgery. However, it has been demonstrated that therapy with these types of medications does not affect the incidence of jaw osteonecrosis in children and adolescents (7,8). Bisphosphonates act on bone metabolism by inhibiting the differentiation and function of osteoclastic cells.

Compared to healthy patients, individuals with OI undergo longer and more forceful orthodontic treatments. Nevertheless, achieving the predetermined orthodontic goal may be difficult, if possible, in some cases. When patients with OI are still in the growth phase, the overall delay in bone growth, especially in the jaw, must be considered. During the mixed dentition period, the clinician must monitor the eruption of permanent teeth and, when necessary, facilitate this movement with orthodontic therapies. The most common teeth that encounter difficulties in eruption are canines, premolars, and second molars, with a higher incidence in the lower arch, except for second molars. Another characteristic is the absence of permanent germs, with common agenesis occurring in second premolars, first molars, and canines (9).

Growing individuals are treated with external orthopedic devices such as the Frankel appliance, which improves facial profile by limiting anterior crossbite. The treatment moderates the speed of dental eruption, aiming to guide the eruption of these teeth to the occlusal plane. In cases of diagnosis of a high-arched palate, a palatal expander is used. Special attention is paid during the active phase by suspending bisphosphonate treatment. The palatal suture ossifies one year after the end of therapy.

For adult patients, the procedure involves a collaborative effort among various branches of dentistry, including orthodontics, surgery, and prosthodontics. It is advisable to consult with the patient's orthopedic doctor to suspend pharmacological therapy before proceeding with the surgical step. The process begins with orth-

odontic preparation, followed by Le Fort I or II surgery, depending on the case, to achieve sagittal advancement of the jaw. Most surgical treatments do not present significant complications; however, in some cases, there may be an increased risk of bleeding. Protocols for a 2-step approach to bimaxillary surgery have been developed to minimize the risk of hemorrhage. Considering the slowed bone healing, the intermaxillary fixation phase should be approximately 5-6 weeks. The stability of the orthodontic result is confirmed over time, with no evidence of bone nor periodontal ligament necrosis (7,8,10,11).

The postoperative period for individuals with OI is known to be longer, with complications such as edema and bruising due to the extended and persistent fragility of blood vessel walls.

Conclusion

Patients with OI are often treated with pharmacological clinical protocols involving the use of bisphosphonates. Biologically, bisphosphonates inhibit the differentiation and, consequently, the function of osteoclastic cells, thereby reducing the risk of bone fractures and increasing the structures' density. Consequently, the difficulty and the complexity of orthodontic and surgical treatments are increased. In the strictly orthognathic field, treatments for such individuals are longer and more challenging. Depending on their developmental age, understanding how to approach treating patients with OI is crucial. During the childhood and adolescence, especially when the patient is in a mixed dentition phase, a higher percentage of agenesis may be observed (particularly of premolars, first molars, and canines). It is also essential to facilitate the eruption of slower-developing elements (canines, premolars, and second molars). Regarding adult patients, it is necessary to first consult with the orthopedic doctor overseeing the patient to plan the suspension of pharmacological therapy. Subsequently, developing a comprehensive treatment plan involving orthodontic, surgical, and prosthetic interventions is important. In the latter two cases, it is crucial to consider the slower healing periods.

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