CHAPTER 39

OSTEOGENESIS IMPERFECTA: Implications in Podiatric Surgery

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Osteogenesis imperfecta (OI) is a connective tissue disorder affecting the collagen portion of the skeletal system. OI patients often present with bone fragility and musculoskeletal deformity, including ligament laxity. As a result of the significant weight-bearing demands placed upon it, the human foot is a frequent area of clinical symptomatology. When conservative management fails, surgical intervention may be indicated. Special considerations for this patient population and a case study are presented.

The term osteogenesis imperfecta refers to a multi-variant disease syndrome related to a inheritable defect of the type I collagen. Because this collagen is the most abundant structural protein in the human body, there can be some significant physical consequences. The most notable features of this disease are brittle bones, ligament laxity, blue sclera, hearing loss, and abnormalities of dentition. The former two, brittle bones and ligament laxity, will be discussed in greater detail because of their potential impact on the foot and ankle.

ASSOCIATED CLINICAL FEATURES

In patients with OI, the sclera can vary in color from normal, to a slightly bluish or slate color to a bright blue. The blueness is caused by a thinning or a transparency of the collagen fibers of the sclera. This allows the choroid layer of the eye to be seen. When seen independent of bone fragility, blue sclera may represent some other form of inherited disorder.

When hearing loss occurs in conjunction with OI, it typically begins during the second decade of life or later. It arises from impaired transmission through the middle ear as far as the footplate of the stapes. Histological changes include deficient ossification, persistence of cartilage areas normally ossified, and calcified strial deposits.

Dentition abnormalities are referred to as dentinogenesis imperfecta. Although the enamel is relatively normal, the teeth have an amber, yellowish-brown or translucent bluish-gray color due to the improper deposition of dentine. The deciduous teeth are usually smaller than normal whereas the permanent teeth are bell-shaped and constricted at the base. Similar and often indistinguishable tooth defects can also be inherited independently of OI.

Other less common and acknowledged findings in OI patients include cardiovascular manifestations such as aortic regurgitation, floppy mitral valves, mitral incompetence, and fragility of large blood vessels. Hypermetabolic states can occur with elevated serum thyroxine levels, hyperthermia, and excessive sweating. In more subtle cases of OI, these associated findings may be the most obvious presenting symptoms.

CLASSIFICATION

In 1981, Sillence presented a classification scheme for OI patients based on clinical manifestations and mode of inheritance.[1] This classification scheme is commonly employed in clinical practice by most treating specialists. Sillence divides the disorder into four types. Type I disease is generally considered to be the mildest form of OI and occurs with a frequency of approximately 1:30,000. It is a mild to moderately severe form that is inherited as an autosomal dominant trait. A high percentage of these patients have associated blue sclerae. Physical expression in type 1 individuals can vary and when mild may lead to the misconception of skipping a generation.

Type II is the most severe form of the disease and is most often lethal. Although most commonly thought to be an autosomal recessive transmission, new genetic mutations are being discovered that make it sporadic. In type II, bones and other connective tissue are so fragile that death occurs in utero, during delivery, or within a few weeks after birth.

Types III and IV are considered to be intermediate in severity between types I and II. Inheritance is thought to be autosomal recessive in type III patients. However, new autosomal dominant mutations are being discovered that make it

difficult to distinguish. Type IV mutations are thought to be autosomal dominant. This patient population most closely resembles in clinical expression those in the type I group.

As genetic and molecular research continues, significant information is being acquired and new forms of gene mutation are being discovered. This will demand new or at the very least expanded classification systems in the future. In fact, in September of 2000 Glorieux et al.[2] revealed a new variant of the disease and called it OI type V. This form differs from the other four types in that it does not appear to be associated with collagen type I mutations. The exact genetic defect underlying this syndrome remains to be elucidated.

SKELETAL AND LIGAMENTOUS CONSIDERATIONS

The most heralded feature of OI is the varying degree of bone fragility that patients possess. The diagnosis is made by excluding other heritable defects or environmental factors that produce osteopenia or osteoporosis and by establishing that the mutation is expressed in more than one connective tissue. If multiple fractures are seen early in life in conjunction with other associated disorders (especially blue sclerae), a diagnosis of OI can be made with confidence. In more mild forms of the disease, fractures may not present until after menopause. In these circumstances, OI must be carefully distinguished from postmenopausal osteoporosis.

In type I patients, the quantity and quality of bone destruction can vary significantly. It can be marked and result in substantial physical disability or so mild that it does not become clinically significant. Type II disease, as mentioned previously, produces profound bone and connective tissue weakness resulting in early mortality. Although less pronounced than in type II disease, types III and IV OI can also result in frequent fracture episodes. These often result from minor stress, but may lead to a stunting of growth and to skeletal abnormalities. Many patients will have an increase in fractures during childhood, a decrease after puberty, and an increase with pregnancy and after menopause. When the spinal column is involved, severe kyphoscoliosis may result producing respiratory impairment and predisposition to pulmonary infections.

Although there is no general consensus regarding the exact morphologic changes occurring in the osseous tissue, bone density is known to be decreased in unfractured bone. Abnormalities have been documented in both the cellular and osteoid components of bone in OI patients. In type II OI, many irregularities exist including thin cortical bone, sparse trabecular bone, increased numbers of osteoclasts and osteocytes, thin osteoid with thin collagen fibrils and patchy mineralization patterns. Generally speaking, the ability to repair the fractures that occur is normal in osteogenesis imperfecta.

Considering the fact that human ligamentous tissue is comprised primarily of type I collagen, ligamentous laxity and joint hypermobility can be expected in patients suffering with OI. Subluxations and dislocations of both upper and lower extremity joints are well documented in the literature.[3-5] Some patients will show skin and joint changes that are indistinguishable from those of Ehlers-Danlos syndrome. General orthopedic manifestations include fractures and bowing of long bones, scoliosis, genu valgum and coax vara.

PODIATRIC CONSIDERATIONS

Aside from the risk of multiple stress fractures, the most common pedal deformity noted in patients with OI is pes planovalgus. Recently, Mirzayan et al.[6] reported two cases of skewfoot in a patient with OI. These patients presented with severe structural deformity of the foot in addition to the ligamentous laxity associated with OI. This combination of deformities presents a tremendous challenge to the treating physician.

The podiatric physician plays a vital role in the treatment of these patients. When the condition is mild, conservative orthotic management or bracing may be sufficient to offset the musculoskeletal weakness and secondary articular collapse. In more severe cases, surgical correction may be required. Both osseous and soft tissue considerations must be taken into account during the surgical planning. Operative intervention in patients with OI requires the surgeon to possess excellent diagnostic as well as technical skills.

CASE PRESENTATION

J.S. is a 23-year-old male who presented with bilateral foot pain, with the left being greater than the right. His pain was concentrated along the lateral aspect of the rearfoot just below the ankle joint. He

complained of pain that was present throughout most of the day and was greatly aggravated by his employment as a waiter. He related pain in both feet that dates back to early childhood. He wore custom orthotics for many years until he was a teenager. Due to cosmetic concerns, he switched to over-the-counter inserts during his high school years. After suffering numerous stress fractures in both feet in this interim, he returned to custom devices last year. Other than the temporary immobilization techniques used during his periods of fracture repair, no other treatment had been rendered. After failing to respond to the orthotic management, he was referred to the author for surgical consultation.

His past medical history was positive for type I osteogenesis imperfecta. The diagnosis was made at 8 years of age by his orthopedic surgeon who treated him on multiple occasions for a variety of fractures. Following an extensive endocrinology work-up, it was determined that his disease was moderate and limited to skeletal fragility and articular hypermobility. The only other associated finding was blue sclerae, which presented no significant clinical symptomatology. His fracture history was extensive. It included four upper extremity injuries and 6 in the lower limbs. All of these occurred as a result of no or minimal injury. There were three pedal stress fractures included in the lower extremity injuries. Only one of the upper extremity fractures required open reduction and internal fixation. Healing occurred in a timely fashion with conservative immobilization therapy in all other instances. Yearly bone density studies are performed to monitor his disease, and he is currently on no medications. He continues to be active and regularly engages in hiking for exercise.

Clinically, the patient presented with severe collapsing pes valgo planus deformity of both extremities. Subjectively, the left was more of a concern though objectively the deformity was bilaterally symmetrical. Range-of-motion examination revealed extreme mobility at the subtalar and midtarsal joints. There was no crepitance or rigidity noted during the evaluation. Stance and gait assessments demonstrated a maximally-pronated foot that remained unchanged during all phases of ambulation. There was no appreciable equinus contracture of either limb. Weightbearing radiographs confirmed severe transverse and frontal plane subluxations occurring at the subtalar and midtarsal joints. (Fig. 1) Profound loss of bone density was also noted throughout the entire foot.

During the surgical consultation, several important considerations were addressed. The degree of clinical deformity demanded aggressive procedures regardless of whether joint salvage or joint destructive procedures were used. The connective tissue portion of the disease and its consequential ligament laxity made soft tissue repairs risky and may potentially result in little benefit. The extreme osseous fragility and his active life style presented possible complications if arthrodesing techniques were used. Following extensive weighing of the pros and cons of each

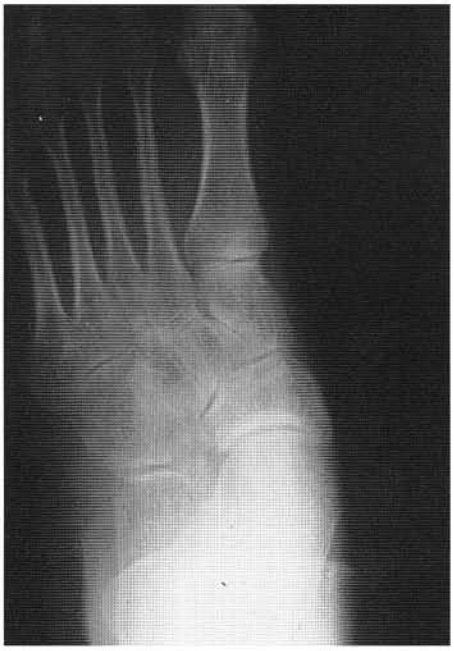

Figure 1A. Preoperative anterior-posterior weightbearing radiograph. Note the severe transverse and frontal plane subluxations. Profound osteopenia is readily apparent throughout the entire foot.

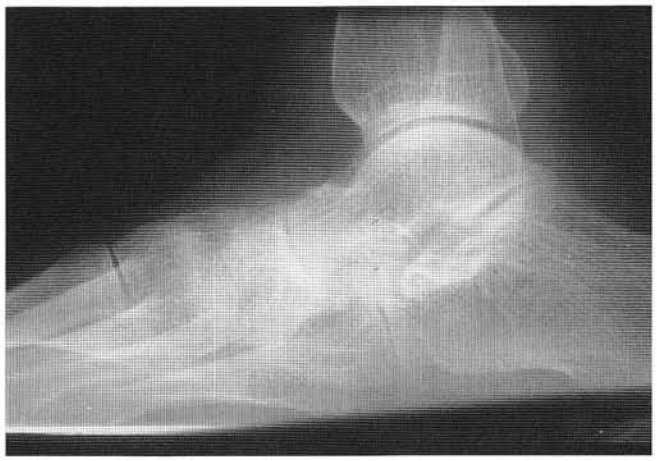

Figure 1B. Lateral preoperative radiograph.

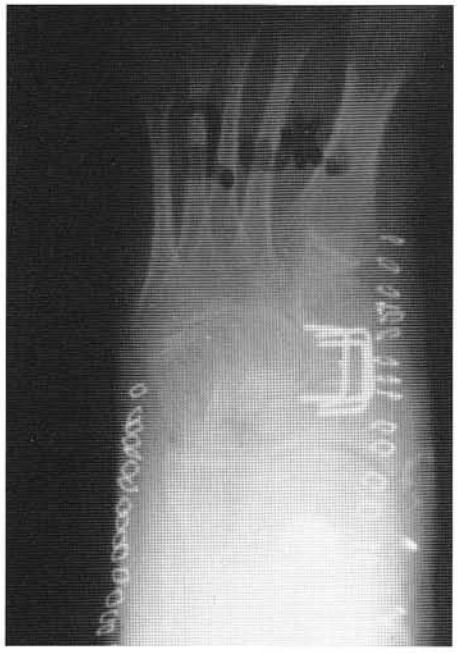

Figure 2A. Immediate postoperative anterior-posterior view. Structural correction and stabilization in all three planes has been achieved.

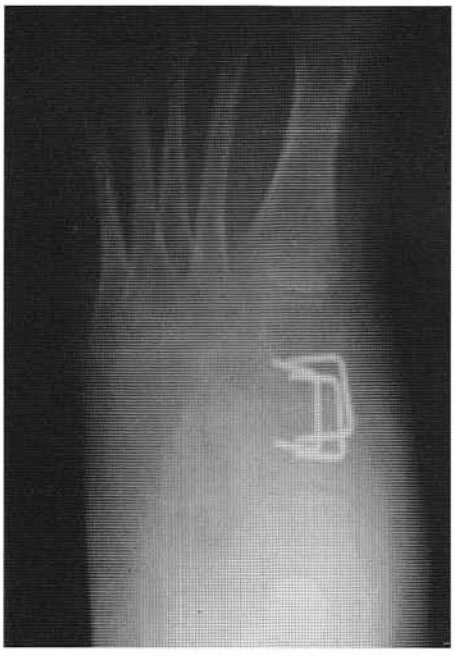

Figure 3A. Eight-week anterior-posterior postoperative view demonstrates good consolidation at both arthrodesis sites.

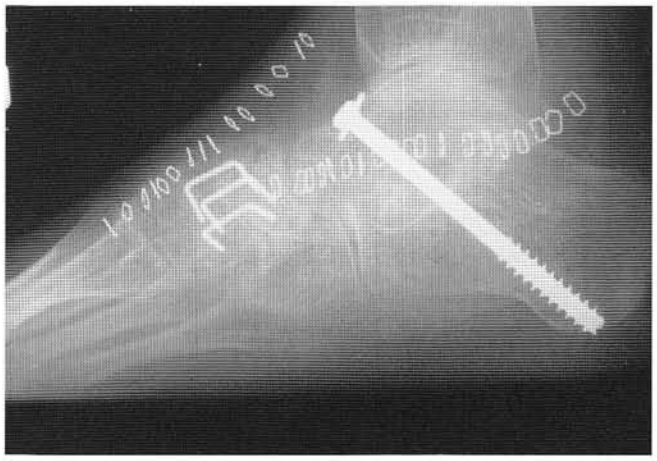

Figure 2B. Lateral view.

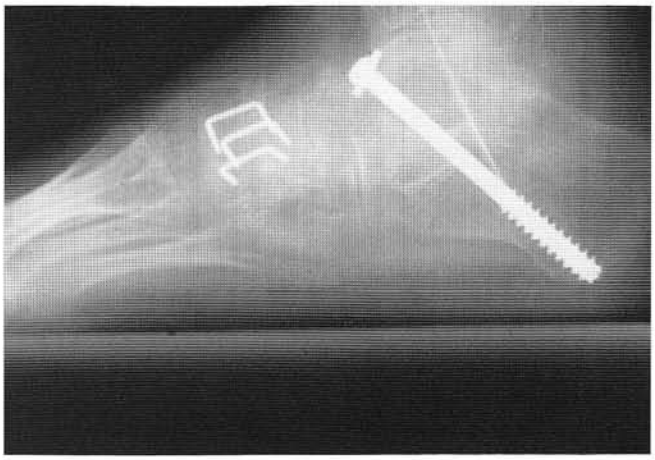

Figure 3B. Eight-week lateral postoperative radiograph.

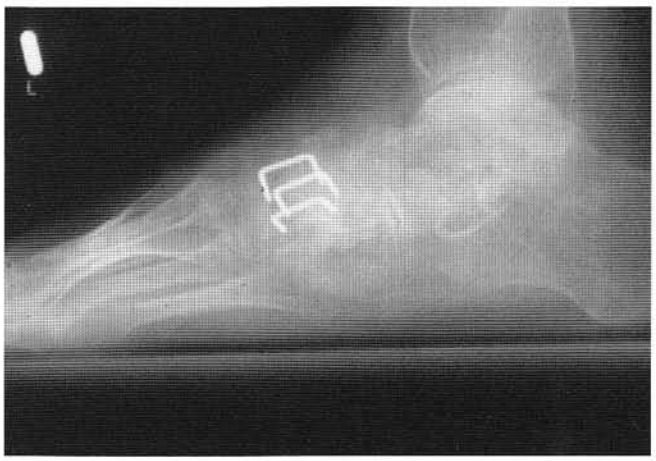

Figure 4. Twelve-week postoperative radiograph following removal of the subtalar internal fixation screw.

alternative, subtalar and navicular-cuneiform joint arthrodesis were selected. (Fig. 2) The procedures were executed without significant problems. The diminished bone density did mandate the use of a washer when the internal fixation screw was delivered across the subtalar joint. Stainless steel staples were used to stabilize the navicular-cuneiform articulation.

The postoperative recovery was uneventful and complete consolidation occurred at both joints in approximately 8 weeks. (Fig. 3) A gradual and deliberate return to weightbearing was initiated at 9 weeks under the care and observation of a physical therapist. A decision was made to remove the subtalar joint screw at 12 weeks. (Fig. 4) This was done in order to allow as much natural strengthening to the bones as possible and eliminate the possibility of secondary stress fracture around the screw. The patient is currently 10 months postoperative, and functioning without pain. He has returned to hiking on a modified basis and continues to be employed in a weightbearing occupation. New custom orthotic devices were fabricated for both feet. The contralateral right foot continues to slowly decline in status and will probably require surgical intervention within a year.

SUMMARY

Osteogenesis imperfecta presents significant challenges to both the patient and treating medical team. In many instances, the podiatric physician plays an important role in the patient's medical health. When conservative modalities, including strict biomechanical control, fail to control symptoms, surgical intervention should be entertained. The severe osseous and ligamentous deficiencies present sizeable obstacles to a successful long-term outcome. The classification of disease, the patient's age, and activity the status will help determine the most appropriate procedures.

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