Supplementation of Autogenous Bone Graft With Coralline Hydroxyapatite in Posterior Spine Fusion for Idiopathic Adolescent Scoliosis

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Abstract

Twenty-seven consecutive patients with adolescent idiopathic scoliosis underwent posterior spinal fusion with pediatric Texas Scottish Rite Hospital instrumentation. Coralline hydroxyapatite (Interpore, Irvine, Calif.) was mixed with limited autograft from posterior iliac crest (an approximate 70/30 ratio of coralline hydroxyapatite to autograft). Patient evaluation was based on clinical and radiographic findings. On initial radiographic evaluation, a “snowstorm” appearance consistent with the exoskeleton of the coralline hydroxyapatite was observed. After two years, the fusion mass had a “marble-like” appearance with distinct decreased visibility of the disk spaces in the fusion mass. This latter stage of “marbilization” correlated with solid fusion clinically. All patients achieved solid fusion at an average follow-up of 27 months.

Coralline hydroxyapatite is safe, biocompatible, and effective in augmenting autogenous bone graft in the treatment of idiopathic adolescent scoliosis with posterior spinal fusion. In addition to decreased donor site morbidity, this may be invaluable in cases where there is insufficient autograft available.

Coralline hydroxyapatite has been used in clinical orthopedics for long bone fractures and filling of osseous defects. It is a sterile, nonosteogenic granular bone void filler similar in structure and composition to human cancellous bone. It is derived from the exoskeleton of marine coral, which has a natural trabecular structure.

The use of autograft harvested from the iliac crest has been well documented in the literature to have significant morbidity including neurovascular injury, infection, fracture of the ilium, donor site pain, and cosmetic deformities.\(^1\)\(^-\)\(^4\)

Compared to autograft in the treatment of idiopathic scoliosis with posterior spinal fusion, there is a significant reduction of operative time and reduced hospital stay with the use of allograft.\(^5\)\(^,\)\(^6\)

Bone allograft has been shown to be an effective alternative in the treatment of idiopathic adolescent scoliosis with posterior spinal fusion with Cotrel-Dubousset instrumentation.\(^7\) However, the use of allograft still carries the possibility of disease transmission and immune reaction.\(^8\)

Zdeblick et al\(^9\) used coralline hydroxyapatite in anterior cervical spine fusion with instrumentation in goats. They concluded that coralline hydroxyapatite had an excellent biologic compatibility with good early creeping substitution of the implant by host bone. Coralline hydroxyapatite also has been used in sheep for posterolateral fusion of the spine and results were equivalent to autograft.\(^10\)

Kucharzyk\(^7\) showed coralline hydroxyapatite to be effective in supplementing autogenous bone graft in 148 patients undergoing posterior spinal fusion for various conditions including failed back syndrome, spondylolisthesis, spinal stenosis, and degenerative disk disease.

This study evaluated the efficacy of coralline hydroxyapatite as supplementation to autograft in idiopathic adolescent scoliosis based on pseudoarthrosis, rejection, safety, and perioperative complications.

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MATERIALS AND METHODS

Twenty-seven patients (25 girls and 2 boys) with a diagnosis of adolescent idiopathic scoliosis underwent posterior or spinal fusion with Texas Scottish Rite Hospital instrumentation. Average patient age was 13 years, 11 months. Parents of the patients were given a detailed explanation and informed consent about the use of coralline hydroxyapatite as augmentation to bone autograft. The average preoperative thoracic and lumbar curves were 64° and 34°, respectively. Selection of fusion levels was based on curve type, magnitude, and flexibility of the curve.

All patients were given general anesthesia and placed prone on a Wilson frame (Orthopaedic Systems Incorporated, NJ). All patients were monitored with sensory and motor-evoked potentials. Cell saver was used as autologous or donor directed blood transfusion, as needed. Using a posterior or midline approach over the area, the posterior elements were visualized. The Texas Scottish Rite Hospital instrumentation was applied in a routine fashion and the posterior elements, exclusive of the areas involved in hook purchase, were decorticated with a burr.

A second oblique incision over the posterior iliac crest was made. A straight osteotome was used to create a rectangular trap door over the posterior iliac crest. A curved osteotome was then used to harvest cancellous bone, and bone wax was applied to all raw bony surfaces to secure hemostasis.

Coralline hydroxyapatite (Interpore, Irvine, Calif.) was applied after posterior or iliac crest bone graft with an approximate 70/30 ratio of coralline hydroxyapatite to autograft. Depending on the number of levels fused, 30 or 60 cc of coralline hydroxyapatite were used.

The two incisions were closed in layers with drains in the subcutaneous layer using absorbable sutures. A thoracolumbar-sacral orthosis was applied at the end of the operation.

On the second postoperative day, drains were removed and patients were allowed out of bed. The thoracolumbar-sacral orthosis was worn for 6 months and was only removed at night and for bathing purposes. Patients underwent follow-up at 2, 4, and 6 months and thereafter at 6-month intervals with radiographs and physical examination. At latest follow-up, all patients were at least 2 years post fusion. All radiographs were evaluated by the senior author (J.J.T.).

All radiographs were taken in the same radiology department using a standardized protocol. This involved the use of long cassette films at a distance of 72 inches from the radiograph tube at a setting of 72 kV and 55 mA seconds.

Pseudoarthrosis was evaluated using radiographic and clinical data. Pseudoarthrosis was suspected if one or more of the following were present: major instrumentation failure (eg, rod breakage), persistent back pain, pain with percussion of the fusion mass, lack of bridging callus, areas of lucency, or lack of a solid fusion mass.5,11,12

RESULTS

All 27 patients had a solid fusion at most recent follow-up. The average curve correction was 69% and 59% for the thoracic and lumbar curves, respectively, and the average loss of correction was 9%. There were 3 complications. One patient had a superficial wound infection that was treated nonoperatively with intravenous antibiotics. One patient had a deep infection requiring open debridement, irrigation, and removal of all hardware 11 months postoperatively. Both patients had solid fusion at latest follow-up. The third patient had one proximal hook dislodge without loss of correction or significant change in hardware position. This patient remained asymptomatic and did not require operative revision. Based on our criteria, no patient had any clinical or radiographic evidence of pseudoarthrosis.

DISCUSSION

In our series of 27 patients with idiopathic adolescent scoliosis, all had solid fusion with the use of autograft supplemented with coralline hydroxyapatite. We believe limited bone harvested due to supplementation with coralline hydroxyapatite contributed to the absence of significant donor site morbidity.

The overall infection rate was 7.4%. The deep infection rate was 3.7%. Studies have shown an average infection rate of 4.4% in patients undergoing fusion for idiopathic scoliosis supplemented with allograft with or without autograft.13,14 The average deep infection rate in three studies in which autograft alone was used was 6.1%.15-17 Therefore, we do not believe coralline hydroxyapatite contributed to our deep infection rate.

Studies have shown major advantages to using coralline hydroxyapatite as an implant. It is biocompatible, biodegradable, nonallergenic, and nontoxic. There has been no sign of inflammatory cells or immunologically reactive cells and no evidence of adverse reaction or rejection of the implant in animal and human studies.18

Coralline hydroxyapatite is an osteoconductive agent providing scaffolding for bony ingrowth. It has been suggested that coralline hydroxyapatite has sufficient affinity for local growth factors that promote regeneration and when placed in muscle puch, demonstrates only bone growth.19 On the contrary, Begley et al20 concluded that the consensus in the literature is that there are no osteoinductive properties associated with hydroxyapatite.

Coralline hydroxyapatite is available as Pro Osteon 200 and 500 (Interpore) with an average pore size of 200 and 500 µm, respectively. Animal studies have shown that the 500-µm pore size results in substantially more bone production at 12 and 26 weeks.21 Pro Osteon 500 is derived from the exoskeleton of marine coral, which has a natural trabecular structure. This structure resembles the multidirectional, interconnected porosity of human can-
cellular bone. The coralline hydroxyapatite used in this study was exclusively Pro Osteon 500.

Holmes et al.22 created defects in the proximal tibia of dogs. Histometric analysis showed 66.5% of the surface of coralline hydroxyapatite covered with bone ingrowth by 12 months.

Biomechanically, coralline hydroxyapatite has been shown in canine studies to be superior to autograft with predictable osseous ingrowth, greater percent increase in radiographic density, higher ultimate compressive strength, and lower stiffness with incorporation.23 Fused coralline hydroxyapatite graft in rabbit radii have been shown to have bending strength similar to that of normal bone.24 In a clinical setting, it is not possible to evaluate the success of fusion by biomechanical testing.

The average cost of coralline hydroxyapatite used in our study was approximately $800. We believe the reduction in operative time and donor site morbidity justifies the cost.12,25

The radiographic appearance of coralline hydroxyapatite incorporation has been studied extensively. Immediately after implantation, radiographs reveal the exoskeleton structure of the sea corals from which the coralline hydroxyapatite is derived.26

Sartoris et al.27 observed that, “progressive obliteration of post-surgical defects at implant-native bone interfaces reflects osseous ingrowth, whereas the slight loss of distinctness of implant architecture and margins is related to apposition of host osteoid to the graft surfaces.” There is indefinite persistence of the coralline hydroxyapatite as a scaffold without significant resorption or remodeling into native bone.27

These radiographic studies have mostly been performed on humans or animals using coralline hydroxyapatite to fill metaphyseal defects as opposed to the use of coralline hydroxyapatite as an onlay graft in the spine.

As in other studies, the initial exoskeleton of the coralline hydroxyapatite is visible and distinctive and remains so for approximately 7-10 years (Figure 1).19 With this “snowstorm-like” appearance, the vertebral bodies and disk spaces remain visible through the graft (Figure 2). By 24 months, there is a “marble-like” appearance of the fusion mass. We believe this is the superimposition of forming bone graft on the “snowstorm” appearance of the coralline hydroxyapatite, which has not been absorbed by the body. With experience, we found it was possible to evaluate bone graft incorporation and formation by noting the distinct decreased visibility of disk spaces in the fusion segments (Figure 3). We believe the “marble-like” appearance signifies solid fusion and correlates well with clinical evidence of fusion. Based on clinical and radiographic results, no evidence of pseudoarthrosis was present.

We continue to use coralline hydroxyapatite as a supplement to autograft in posterior spinal fusion for idiopathic adolescent scoliosis at our institution. The use of coralline hydroxyapatite along with synthesized bone morphogenetic protein without the use of autograft is being investigated.

Coralline hydroxyapatite is a safe and effective supplementing implant for use with autograft for the treatment of adolescent idiopathic scoliosis with posterior spinal fusion.

Figure 1: Postoperative AP radiograph shows the architecture of the coral exoskeleton. Figure 2: AP radiograph 1 year postoperatively shows the “snowstorm” appearance of the fusion mass. Figure 3: AP radiograph 2 years postoperatively shows the “marble-like” appearance of the fusion mass.

REFERENCES
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