CHAPTER 46

CURRENT CONCEPTS OF ARTICULAR CARTILAGE RESURFACING TECHNIQUES

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Hippocrates was the first to recognize the limited potential of articular cartilage to either heal or to regenerate under ordinary circumstances. Since cartilage is devoid of vascularity and innervation, this tissue has led to challenges in successful repair in joint disease. Deforming forces on the lower extremity are very often the culprit in damaging articular cartilage. Many pathologists report that damaging articular cartilage is the first step in degenerative joint disease. As our health-conscious environment continues to encourage an increase in exercise and physical activity, degenerative joint disease will be a predictable condition the podiatric physician will encounter with increasing frequency. This paper will address current concepts of cartilage repair and potential applications to the foot and ankle joint.

Current treatment modalities for damaged articular cartilage in the lower extremity (hallux limitus/rigidus, Freiberg's infraction, talar dome lesions, etc.) can be categorized as either salvage or destructive procedures. The salvage procedures include techniques of subchondral drilling, and abrasion arthroplasty. Destructive procedures may include arthrodesis, joint arthroplasty, and arthroplasty with implantation. All of these procedures have their disadvantages. Arthrodesis has been reported to yield a good result, but requires precise surgical technique, some type of internal fixation and prolonged postoperative recovery. Arthrodesis may also create increased stress across adjacent joints, and limit the patient's selection of shoes. Resectional arthroplasty has led to less predictable results in which the joint is shortened and loses strength. Implants (particularly silicone) have resulted in foreign body reaction, synovitis, destructive bone changes, and implant failures. Subchondral drilling and abrasion arthroplasty techniques result in a fibrous joint secondary to the formation of Type I collagen, and cannot be considered a true joint salvage procedure.

The authors believe that if an effective means of resurfacing damaged cartilage can be established, then the potential for successful joint salvage will increase dramatically. As the evolving technology continues to improve, the podiatric physician can address and correct the damaged articular cartilage as well as the underlying deforming forces. The latter can be done surgically or with an orthotic device. The end result will be a reconstructed joint which would function for a longer period of time and remain pain-free.

CURRENT CONCEPTS

The shortcomings of the traditional surgical treatments in osteoarthritis justify the continued search for better treatment modalities. Some of the recent developments in articular resurfacing techniques which have been applied to other joints have been promising. If joint salvaging procedures can be used in conjunction with procedures which correct the underlying deformity, there is a greater chance for long-term success. These articular cartilage resurfacing techniques include autologous perichondral transplantation, periosteal resurfacing, and synthetic cartilage.

Autologous Perichondral Transplantation

Autologous perichondral transplantation has recently been applied to full-thickness cartilage defects in the human knee joint.[1] This procedure involves removing healthy cartilage from a part of the unaffected knee, enzymatically digesting the cartilage, and culturing the chondrocytes in a laboratory for 14 to 21 days. The chondrocytes are then injected back into the defect and covered with a periosteal flap. The 23 patients (11 men and 12 women) were followed for an average of 66 months. Follow-up evaluation included arthroscopic evaluation, and clinical and histological biopsy of cartilage. The conclusion of the study

indicated that cultured autologous chondrocytes can be used to repair deep cartilage defects in the femoral-tibial articular surface of the knee. The question as to whether or not this technique can be applied to the joints of the foot has not yet been addressed.

Periosteal Resurfacing

Periosteal resurfacing is another technique which has been recently applied to the lower extremity. Several experiments indicate that periosteum can be used to promote cartilage formation when the cambium layer is in a chondrotrophic environment. Periosteum is well-known to promote osseous healing and bone formation. Interestingly, when periosteum is placed in an immobile environment, it will differentiate into bone. However, if periosteum is placed into a chondrotrophic environment where joint motion is maintained, it has the ability to differentiate into hyaline-like cartilage. A Finnish orthopedic group at the ORTON Invalid Foundation has used various methods of attaching periosteum to the defective articular cartilage.[2] These methods include the use of fibrin glue (Beriplast P Adhesive Set by Behring) and absorbable suture material in order to attach periosteal grafts from the anterior surface of the tibia to the metatarsal head defect. The involved joint is now subjected to active and passive motion.

The results of a recent study indicate that the periosteal resurfacing could be used in the treatment of hallux rigidus and Freiberg's disease.[3] The study involved six patients who could not toe walk or run due to pain. In each case, the preoperative range of motion of the first metatarsophalangeal joint was 10 to 40 degrees. The patients ranged in age from 15 to 39 years, with an average age of 27 years. Average patient follow-up was 8.3 years following the periosteal resurfacing. The subjects were satisfied with the results and had no pain at rest or while walking. Postoperative range of motion was normal (65 to 101 degrees) and the joint spaces were of normal width on radiographs. This study is promising as it applies to the first metatarsophalangeal joint. The authors did not address the underlying deformities which may have predisposed to joint destruction or restricted motion.

One of the authors has attempted this repair in a case of Freiberg's infraction. The fibrin glue which was utilized was improperly mixed and did not result in a proper adhesive to reattach the perichondral graft. Subsequently, the graft became loose and drifted centrally into the joint. Postoperative radiographs showed the ossification of the perichondral graft within the joint, with resultant pain and deformity. The patient ultimately underwent a revisional surgery to remove the graft and debride the joint. Interestingly, the patient complained of anterior tibial pain for nine months after the graft was taken.

Synthetic Cartilage

A final, promising area of study involves synthetic articular cartilage. Much research has involved studying the physical and morphological properties of articular cartilage in order to develop a model. Original designs involving homogenous hydrogels proved to have relatively poor strength, and stiffness.[4] Advances in biomedical engineering and advances in tissue sciences have led to the creation of semi-impenetrating polymer networks which simulate the mechanical properties of articular cartilage.[5] Chondrocytes are incorporated into these polymer substrates and injected into the defects. This research is still in its preliminary stages and currently all studies are either in vitro, or involve animal models, with human studies pending. Studies will not only center around the effectiveness of this compound, but also on the immunological responses which they may elicit.

CONTINUOUS PASSIVE MOTION

A discussion about regenerating articular cartilage cannot be complete without discussing the concept of continuous passive motion and its importance in the postoperative promotion of cartilage. Immobilization has been a time-honored recommendation by many physicians for healing broken bones. However, studies have indicated that the best treatment with which to encourage the repair of cartilage is continuous passive motion.[6] This involves the use of an apparatus which would move the joint through its range of motion at a frequency of at least one complete cycle per minute.

THE FUTURE

The future approach of treating degenerative joint disease may involve the application of articular cartilage resurfacing techniques along with a surgical osteotomy to correct the underlying deformity. The goal of future research in this area will be in developing and testing, in a stepwise manner, the application of cartilage resurfacing techniques to lower extremity conditions such as hallux limitus/rigidus, Freiberg's disease, talar dome lesions and other conditions associated with damaged articular cartilage.

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