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Glenohumeral cartilage defects in the young patient are challenging clinical problems given the longer life expectancy after surgery of these patients and the greater demands their more vigorous lifestyles place on their shoulders. Numerous etiologies can lead to glenohumeral cartilage disease: trauma, instability, inflammatory arthropathies, postinfectious degeneration, foreign body reaction, and glenohumeral chondrolysis.1,2

The initial treatment of glenohumeral cartilage disease is always nonsurgical, but when measures are needed beyond conservative management, there are a variety of treatment options available, including palliative, reparative, restorative, and reconstructive treatments, to guide a clinical management algorithm. Thus, we report on a novel treatment method and discuss the background framework into which it and other pieces are being fitted to improve care of shoulder disorders.

Methods
We hypothesized that a collagen I/III matrix superimposed on a chondral defect that has been concomitantly treated with microfracture will provide a superior medium on which functional cartilage will form and heal.

To test this hypothesis, we divided 12 rabbits into 3 groups. Each group underwent the same surgical approach to the rabbit glenohumeral joint, including incision and repair of the superior rotator cuff. Group 2, the surgical control, consisted of rabbits that underwent removal of the cartilage layer on the glenohumeral joint only. Group 2 rabbits underwent microfracture to the glenohumeral defect (Figure 1). Group 3 underwent the autologous matrix-induced chondrogenesis (AMIC) procedure: microfracture of the glenohumeral defect followed by the application of a collagen I/III matrix (Figure 2). Each rabbit had 1 operative shoulder and 1 control nonoperative shoulder. All operations were completed with the same exposure and closure.

The study was one of a series from this institution that analyzes new biocconstructs and collagen matrices to augment cartilage in shoulder surgery. In this study, we evaluate whether autologous matrix-induced chondrogenesis (AMIC), which involves using a collagen I/III matrix with microfracture, can promote the formation of tissue with similar architecture to native cartilage by organizing adhesion, migration, and differentiation of mesenchymal stem cells to chondrocytes.

In order to understand the potential applications of this basic science research, we have employed a framework of clinical needs, which includes palliative, reparative, restorative, and reconstructive treatments, to guide a clinical management algorithm. Thus, we report on a novel treatment method and discuss the background framework into which it and other pieces are being fitted to improve care of shoulder disorders.

Results
The results for total cartilage volume and average cartilage thickness in both native and operative shoulders are displayed in Figures 3 and 4. There were no significant differences in the statistical results between all groups; however, there was a trend toward increased defect fill and thickness in the microfracture and AMIC groups (Groups 2 and 3, respectively). The topographical surface maps for the surgical control and AMIC procedures are shown in Figure 5, as an illustrative example of the subjective improvement in the AMIC fill patterns. There were also no significant trends in the attenuation values of the defect fill. Post hoc power analysis showed each group would need to have 10 specimens in order to find statistical differences.
few published series, arthroscopic debridement has led to good restorative and reconstructive interventions in the future. In a surgical morbidity, and does not preclude other, more advanced, techniques. Therefore, restorative modalities are best reserved for the young, active individual with a distinct chondral lesion of the humerus or glenoid who has already failed conservative, palliative, and reparative treatment.

REPARATIVE TREATMENTS
Reparative treatment includes marrow stimulation techniques like chondroplasty, subchondral drilling, and microfracture to replace the damaged cartilage with fibrocartilage (Figure 7). However, despite its reported effectiveness in the knee joint, we are aware of only three series that report clinical outcomes following microfracture in the shoulder joint.20–22 Siebold et al.20 and Müller et al.21 reported on small series of patients that underwent microfracture for full-thickness chondral defects. At final follow-up there was a significant improvement in functional scores with an approximately 20% rate of revision procedures.

Our experience has been similar: Frank, Van Thiel, and Cole et al.22 reported minimum 12 months (mean, 28 months) follow-up on 16 patients (17 shoulders) who underwent arthroscopic microfracture of the humeral head or glenoid surface. The 14 patients that were available for follow-up had statistically significant improvements in pain and function. Of the 16 patients, 323% experienced surgical failures and required arthroplasty at a mean of 10.1 months after debridement. Grade IV bipolar disease, joint space less than 2 mm, and the presence of large osteophytes constituted the most significant risk factors for failure. Overall, arthroscopic debridement is a very reasonable and predictable first-line surgical option that offers relief of pain and improvement in functionality in approximately 80% of cases.

DISCUSSION
The current study evaluates whether a collagen I/III matrix with microfracture can promote the formation of tissue with similar architecture to native cartilage by organizing adhesion, migration, and differentiation of mesenchymal stem cells to chondrocytes. The data suggest that both microfracture and autologous matrix-induced chondrogenesis (AMIC) have the ability to fill a glenohumeral cartilage defect in a rabbit model significantly more than the surgical control, based on micro-CT data. Although the current study does not reveal significant differences, there are some very important conclusions that can be drawn. One, further research is needed to characterize the trends seen in this study. We currently have a much larger trial underway that will use histology and MRI to corroborate the results reported here. Two, the rabbit glenohumeral model is a very good in vivo model to study glenohumeral cartilage defects (Figure 6). Overall, this study provides a solid foundation for continued basic science research.

However, basic science research in isolation cannot address the issue of glenohumeral cartilage defects without clinical corollaries. In order to understand the potential applications of this basic science research, we reviewed the aforementioned areas of palliative, reparative, restorative, and reconstructive techniques in the shoulder joint to provide a framework to guide a clinical management algorithm.

PALLIATIVE TREATMENTS
Palliative techniques for the management of glenohumeral cartilage disease are designed to alleviate symptoms without replacing or restoring the injured articular cartilage. These techniques consist primarily of arthroscopic debridement, capsule release, and loose body removal. Arthroscopic debridement is appealing because it is technically straightforward, has low surgical morbidity, and does not preclude other, more advanced, restorative and reconstructive interventions in the future. In a few published series, arthroscopic debridement has led to good or excellent results in roughly 80% of patients at short follow-up intervals.23–25 Cameron et al.26 reported on a series of patients with grade IV osteochondral defects and found that 88% experienced significant improvement in pain and function for an average duration of 28 months. Weinstein et al.27 also reported 80% good or excellent results at a mean follow-up of 34 months.

The largest series in the literature was reported by Van Thiel, Romeo, Verma, Cole et al.22 The authors retrospectively reviewed 81 patients who underwent arthroscopic debridement for glenohumeral osteoarthritis. Of the 81 patients, 71 were available for follow-up at an average of 27 months, and 58 of the 81 (82%) were satisfied with the results of the surgery and would have it again. They also experienced a statistically significant improvement in postoperative functional outcome scores and a decreased level of pain. Of the 71 patients, 16 (23%) experienced surgical failures and required arthroplasty at a mean of 10.1 months after debridement. Grade IV bipolar disease, joint space less than 2 mm, and the presence of large osteophytes constituted the most significant risk factors for failure. Overall, arthroscopic debridement is a very reasonable and predictable first-line surgical option that offers relief of pain and improvement in functionality in approximately 80% of cases.

Figure 5. Topographical maps of the cartilage surface in the two different treatment groups.
Figure 6. Rabbit glenohumeral joint.
Outcomes in the Treatment of Benign Bone Lesions with Bioceramic

“The functional results [of the study] were excellent, complications were infrequent, and the composite bioceramic seems to be a reasonable alternative to autogenous bone graft.”

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B enign bone tumors and cysts are relatively common entities encountered in a general orthopaedic and orthopedic oncology practice. This broad category encompasses lesions with widely varying clinical behaviors and natural histories. Treatment, therefore, must be individualized based on factors such as the specific tissue diagnosis, size of the lesion, location, associated symptoms, risk of pathologic fracture, and individual patient characteristics.

MATERIALS
Traditionally, autogenous bone graft has been the “gold standard” for all grafting procedures.1 Several supply and quality issues exist: the most common problem reported is donor site morbidity, however, this option much less desirable.1,11 Bone-graft substitutes composed of calcium sulfate (GCS®) or calcium phosphate (βTCP or βTCP-HC) are attractive alternatives because they are both bioresorbable and osteoconductive. Furthermore, they do not contain persistent cytokines, which may be contraindicated in the oncology setting. Unfortunately, few data exist in the literature regarding the use of bone-graft substitutes in orthopedic oncology.12 Most of the reported series using surgical grade CaSO4 (1-0.2 of C32HxOyP2O5·mH2O) graft materials to treat patients with benign bone tumors feature relatively small numbers of patients and short-duration follow-up, ranging from 6 to 72 months. Results have been generally acceptable in terms of function and recurrence rates. However, relatively common complications still exist: the most common problem reported is serious bone graft failure.2,4,19 Radiological appearance and demonstration of resorption with bone replacement is unequivocal at best.

In 2008 Wright Medical Technology (Arlington, Tennessee) released Pro-Decor, an injectable CaSO4·H2O (βTCP-50) composite graft, or bioceramic material with high compressive strength and an intermediate degradation profile. A preclinical canine study showed this material to be superior to CaSO4 with regard to the quantity and quality of bone formed in a contained humeral defect.2,10

The bioceramic is a composite graft that integrates a matrix of CaSO4 and dicalcium phosphate dihydrate (DCPD) into which β-tricalcium phosphate (β-TCP or βTCP-HC) granules are distributed.2 The graft is prepared intraproactively by mixing the powdered graft materials with an aqueous diluent, resulting in a doughy substance. Various factors can influence the bone quality of the tissue formed in contained defects.2,5-7 Longer-term clinical results using Pro-Decor in the treatment of bone defects are needed.2,5-7

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REFERENCES