Future Treatment Strategies for Cartilage Repair

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KEYWORDS

• Cartilage repair • Tissue engineering • Cell therapy • Scaffolds • Growth factors

KEY POINTS

- The near future of cartilage repair will most likely involve refinement of current techniques along with incorporation of scientific advances in cartilage biology.
- With further development the implantation of a scaffold imbedded with stem cells and cartilage growth factors will likely be scientifically achievable and it is hoped could be made clinically viable and cost-effective.
- Ongoing research into cartilage repair should offer a single-stage surgical technique, which will replicate the structural characteristics of normal articular (hyaline) cartilage and incorporate onto bone.

INTRODUCTION

Cartilage repair remains a work in progress. Getting cartilage-like material to fill gaps in normal articular cartilage (AC) is possible with a variety of techniques. These replacement tissues have been analyzed for their various properties and bits and pieces of similarities with hyaline cartilage have been found. Cartilage substitutes and even benign neglect have been tried. All these modalities have met with variable success. Proponents of these methods tout the benefit of their specific approach but to date none of them would be considered a solution to cartilage defects for weight-bearing joints.

AC is an especially difficult tissue to induce and/or manufacture. It has a very complex structure and is almost inert with very little blood supply; its supporting cells are primarily for maintenance not repair, and therefore, matrix injury results in a very blunted and inadequate repair response.

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Current strategies for repairing cartilage defects often report clinical success rates of 70% to 80% for pain relief and functional return. Fortunately clinical success is not solely correlated to reproduction of the form and attributes of AC. Many of the repair/replacement techniques compare themselves against the body's ability to repair itself. The tissue formed following microfracture has been popularized as the convenient cartilage repair tissue benchmark. Unfortunately none the techniques that seek to regrow cartilage results in normal AC in either structure or function.

This article summarizes the current techniques and how these techniques may evolve and presents some of the emerging techniques that are not yet in clinical use.

ADVANCES IN CURRENT RESTORATIVE THERAPIES

Although it is appealing to look to novel techniques to advance the science of cartilage repair, it is more likely that incremental advances in current techniques hold the most promise in the near future. The goal of re-establishing the native structure and function of native hyaline AC will take a biologic approach. The treatment of AC lesions is evolving from native tissue transplantation to engineering enhanced tissue, including cell- or gene-based therapy with 3D biodegradable scaffolds and growth factors (**Table 1**).[1–39]

Abrasion arthroplasty was one of the early techniques for surgical cartilage repair. The goal was to remove damaged cartilage and promote a healing response that would provide blood elements that would provide stable fibrocartilage for improved joint function.

Microfracture popularized in 1977 by Steadman and coworkers has been the more recent benchmark for cartilage repair from biologic tissue restorative techniques for pure cartilage defects. Steadman had good results for lesions less than 2.5 cm^2 in young patients.[3] This technique results in fibrocartilage as the repair tissue. As the science of cartilage repair advances, microfracture alone will likely see an increasingly limited role. It will very likely be that it will be used in combination with various growth factor and scaffold options.

Cartilage transplantation techniques were popularized to use hyaline cartilage in place of damaged AC. The use of osteochondral autograft transplantation (OAT) is typically used for lesions less than 4 cm^2 and fresh stored osteochondral allograft transplantation is used for lesions larger than 4 cm^2 (see **Table 1**).

The reported success of OAT procedures ranges from 50% to 80% as good to excellent. Some of the factors limiting success of this procedure include problems of cartilage thickness, graft orientation, graft contour, plug size versus defect size, use of donor versus defect shape mismatch, necessitating multiple round plugs and donor site problems. Currently this technique is best suited for defects less than 4 cm^2 primarily because of limited donor tissue. Changes in the technique that would likely improve the current technique include the following:

1. Allow different shaped donor plugs to accurately match the defect area;
2. Fill the donor site to minimize the defect in both the bone and cartilage;
3. Optimize the surface contour match between donor and recipient areas;
4. Optimize orientation of the cartilage surface for load-bearing and adjacent cartilage shear forces and to match adjacent native cartilage;
5. Assure plug fit so there is exact height match with surrounding surface;
6. Develop gap healing at graft-host boundary with fibrin glue or platelet-rich plasma;
7. Maintain existing chondrocyte viability through transfer (ie, using a no impact technique with graft insertion)